Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

OCTOBER, 1956

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vol 33 #10

TABLE OF CONTENTS, PAGE 53

HIGH-SPEED TANDEM COLD MILLS

esta 56" Four-High, Four-Stand Tandem Cold Mill
talled at the Brackenridge Plant of Allegheny-Ludlum Steel Corp.

Designed and Built by MESTA

FOR THE COLD REDUCTION OF STAINLESS, SILICON, HIGH-ALLOY AND CARBON STEELS

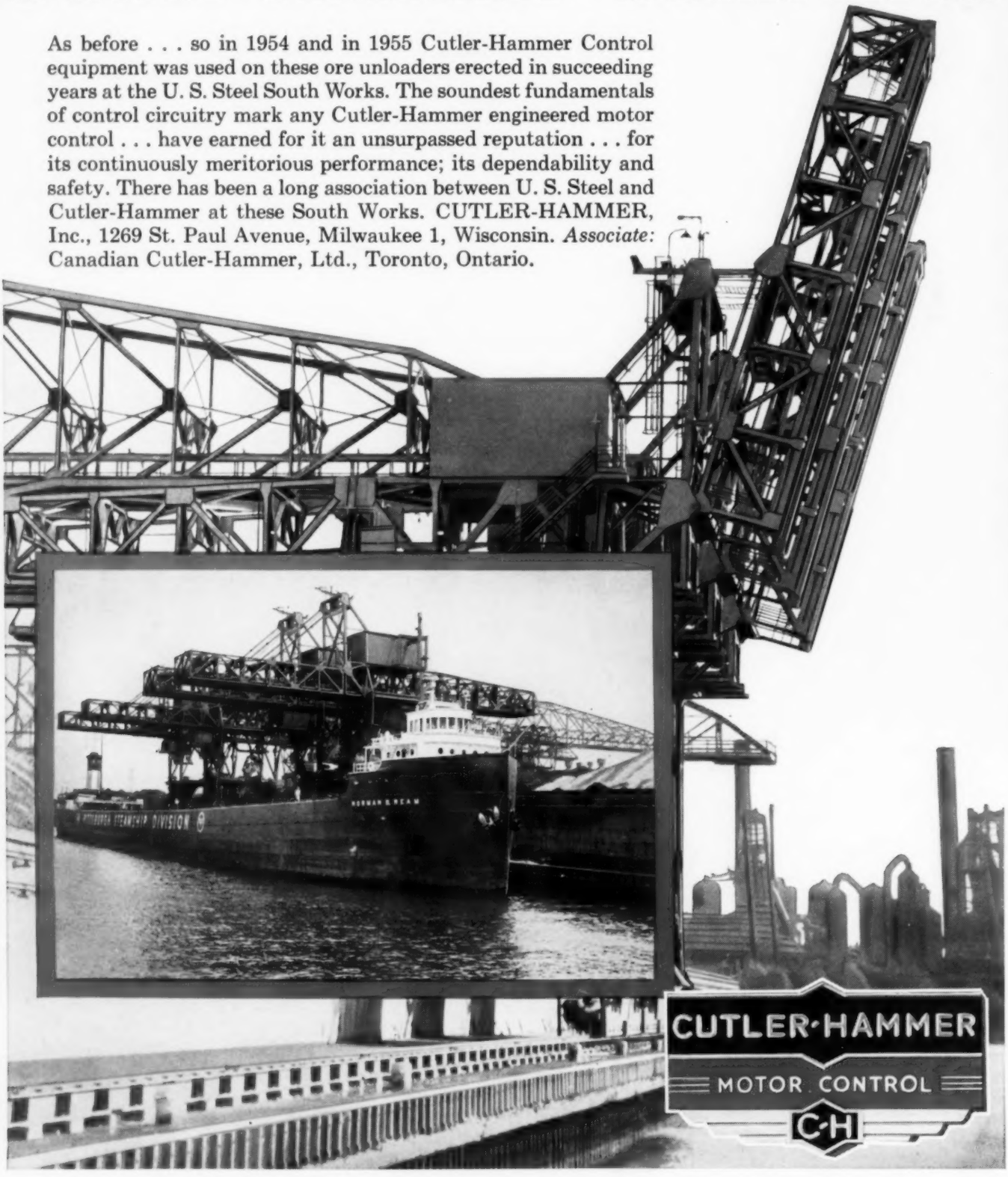
Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

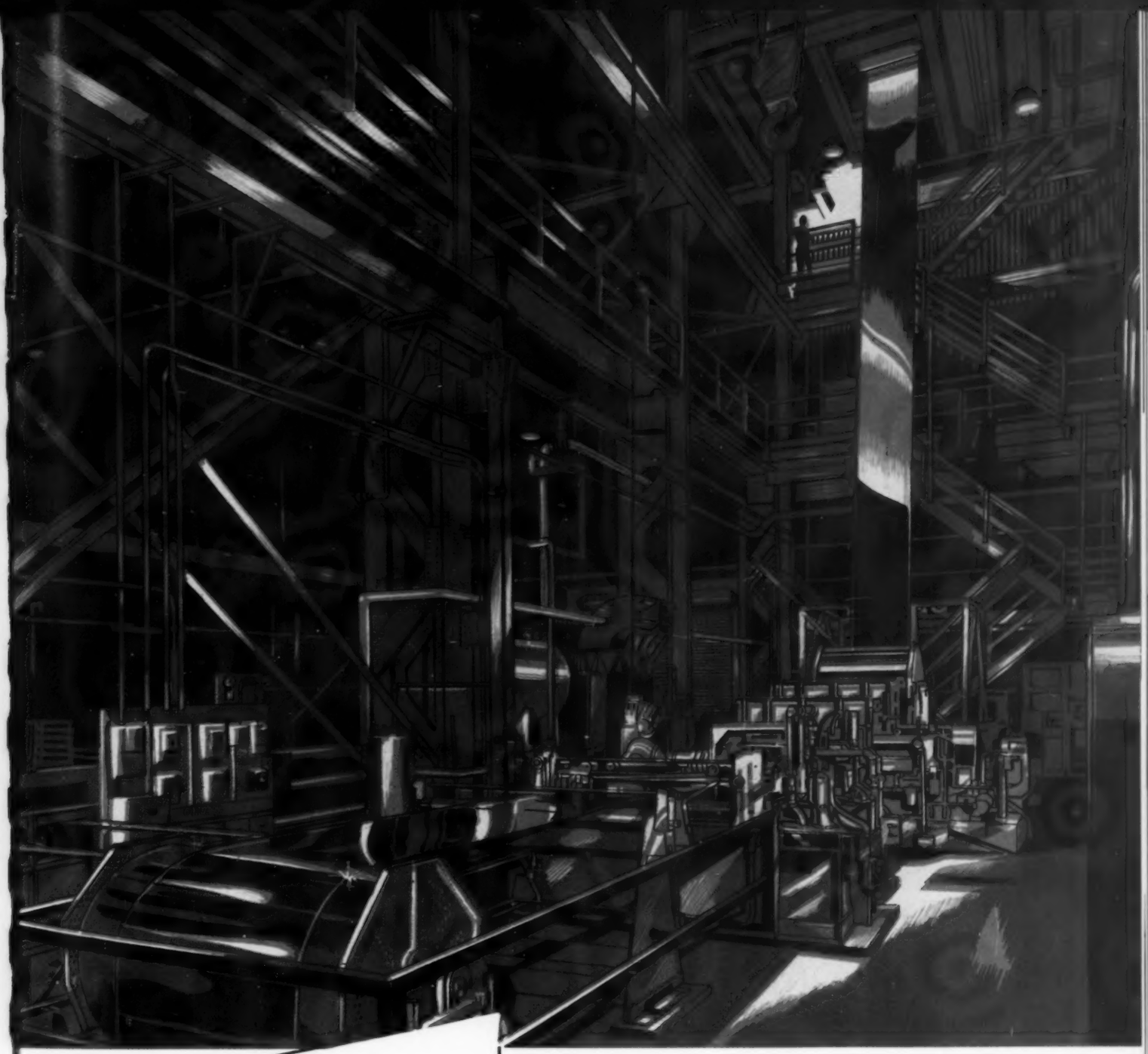
SEVEN GIANTS
at USS South Works
Cutler-Hammer Controlled

As before . . . so in 1954 and in 1955 Cutler-Hammer Control equipment was used on these ore unloaders erected in succeeding years at the U. S. Steel South Works. The soundest fundamentals of control circuitry mark any Cutler-Hammer engineered motor control . . . have earned for it an unsurpassed reputation . . . for its continuously meritorious performance; its dependability and safety. There has been a long association between U. S. Steel and Cutler-Hammer at these South Works. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



LOOK TO CUTLER-HAMMER MILL EXPERIENCE...AS BROAD AS IT IS LONG

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.



New Ideas IN EQUIPMENT FOR CONTINUOUS COATING LINES

• New ideas recently developed by Aetna-Standard make Continuous Coating Lines more efficient. One idea focuses on a new approach for **Loop Cars.** The use of Loop Cars eliminates deep loop pit excavation and keeps strip in full view for easier inspection.

New Aetna ideas contribute to an even better finished product. Space saving in the installation results in lower first cost. There is less equipment to buy and to install.

Aetna-Standard has installed more Continuous Galvanizing Lines than all other manufacturers combined.

AETNA • STANDARD

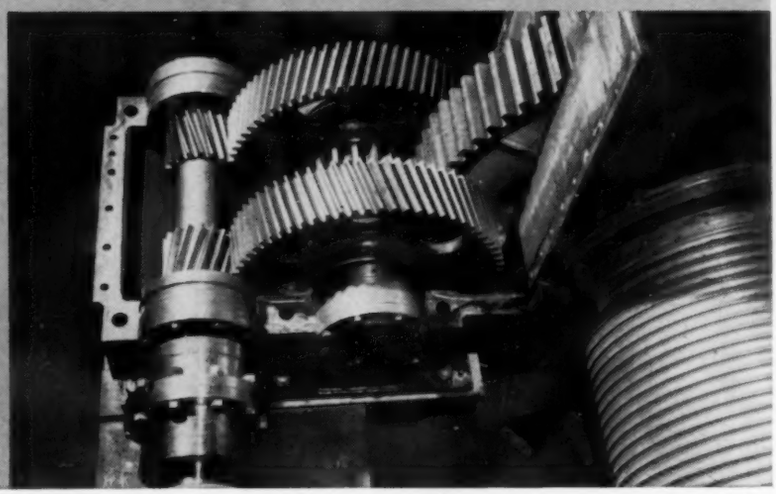
THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. **PLANTS: ELLWOOD CITY, PA., WARREN, OHIO**

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

MAKE SURE YOUR NEXT BULK MATERIALS HANDLING BRIDGE HAS THESE IMPORTANT DRAVO FEATURES:

- Liberal Use of Welded Components
- Double Web Truss System with Beam Sections
- Positive Wind Protection with Dravo Rail Clamps
- Fully Equalized Loading on Truck Wheels
- Trolley Accident Prevention with Dravo Hydraulic Buffers
- USE OF UNIT CONSTRUCTION FOR MECHANICAL ELEMENTS



Gearing for one drum of a trolley hoist—Gears, shaft and bearings in sealed steel cartridges installed as unit assemblies in a heavy, welded, oil tight gear case. Accurate alignment and smooth, quiet operation assured.

DRAVO Ore Bridges...

low maintenance, low operating costs

Unit construction of mechanical parts is only one of the built-in Dravo features that keep maintenance and operating costs down. Each structure is individually designed to handle its specific job economically, dependably and safely. Such performance is achieved by bringing together the customer's operating knowledge and the experience of Dravo's research, design and construction men.

This method has resulted in high efficiency bridges and other bulk materials handling equipment that produce because they are tailored to fit the job. Dravo engineering features, built into every structure, provide for low maintenance and operating costs. For complete information, write to Dravo Corporation, Pittsburgh 25, Pennsylvania.

DRAVO
CORPORATION

DRAVO

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

ONE MAN and CLARK CONTROL operate this giant unloader with capacity of 1100 tons per hr.

An average of 10,000 tons of coal per day is unloaded from river barges at the Ohio Valley Electric Corporation's Kyger Creek power plant, by two Heyl-Patterson rope-trolley unloaders. This plant and another like it at Clifty Creek are the largest privately-owned generating stations in the world—combined capacity 2,365,000 kw—supplying a total of 17 billion kilowatt hours per year for an Ohio atomic energy project.

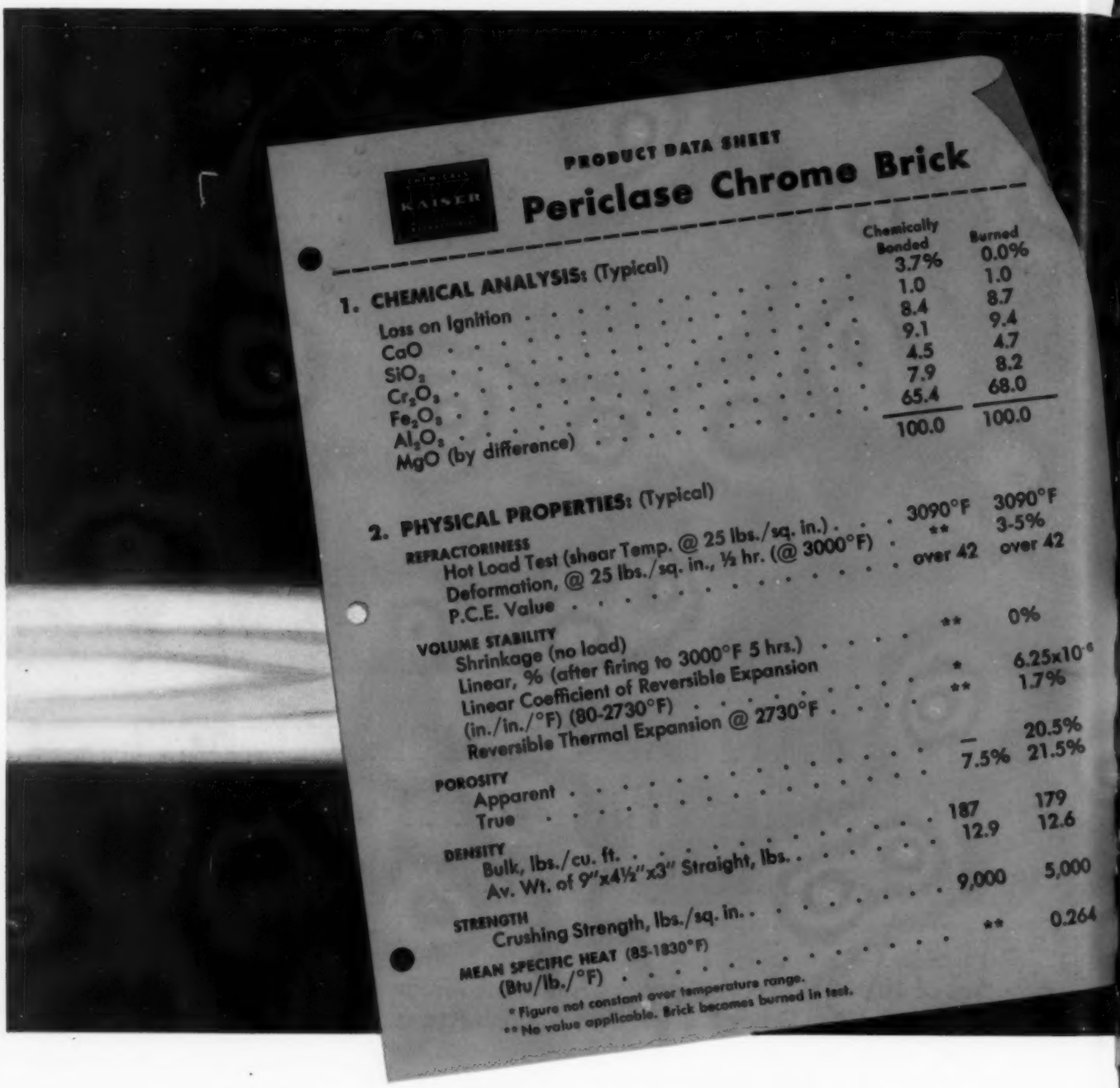
Clark adjustable voltage control systems with magnetic amplifiers, team with Elliott rotating equipment in each unloader to provide maximum unloading rate, smooth acceleration and stopping, high efficiency, low maintenance and long rope life. One man controls the entire operation.

This is another example of greater operating efficiency through Clark-engineered Control. Let us help solve your control problems.

Clark control including magnetic amplifiers, located in motor room atop the tower, provides adjustable voltage control with current limit acceleration, deceleration and dynamic braking for the three drive motors. Note Clark edgewound resistors on top of the cabinet and Clark brake for the trolley motor in the foreground.

The CLARK CONTROLLER Company
Engineered Electrical Control
1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA...CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO


PRODUCT DATA SHEET
Periclase Chrome Brick
KAISER
1. CHEMICAL ANALYSIS: (Typical)
Chemically Bonded
Burned
Loss on Ignition 3.7% 0.0%
CaO 1.0 1.0
SiO2 8.4 8.7
Cr2O3 9.1 9.4
Fe2O3 4.5 4.7
Al2O3 7.9 8.2
MgO (by difference) 65.4 68.0
100.0 100.0
2. PHYSICAL PROPERTIES: (Typical)
REFRACTORINESS
Hot Load Test (shear Temp. @ 25 lbs./sq. in.) 3090°F 3090°F
Deformation, @ 25 lbs./sq. in., ½ hr. (@ 3000°F) ** 3-5%
P.C.E. Value over 42 over 42
VOLUME STABILITY
Shrinkage (no load)
Linear, % (after firing to 3000°F 5 hrs.) ** 0%
Linear Coefficient of Reversible Expansion
(in./in./°F) (80-2730°F) * 6.25x10-6
Reversible Thermal Expansion @ 2730°F ** 1.7%
POROSITY
Apparent — 20.5%
True 7.5% 21.5%
DENSITY
Bulk, lbs./cu. ft. 187 179
Av. Wt. of 9"x4½"x3" Straight, lbs. 12.9 12.6
STRENGTH
Crushing Strength, lbs./sq. in. 9,000 5,000
MEAN SPECIFIC HEAT (85-1830°F)
(Btu/lb./°F) ** 0.264
* Figure not constant over temperature range.
** No value applicable. Brick becomes burned in test.

COMPARE THESE SPECIFICATIONS

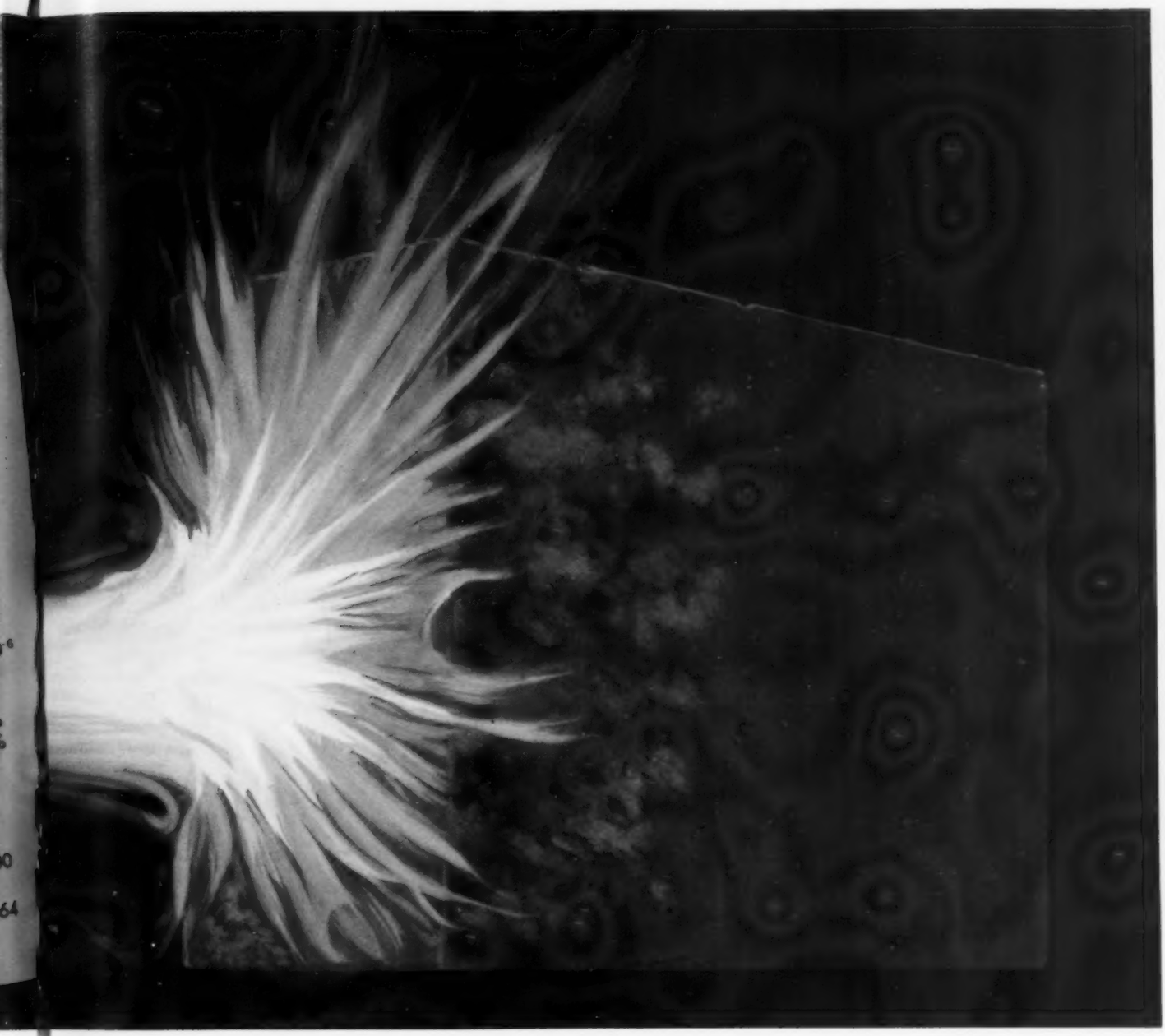
Here's proof that Kaiser Periclase Chrome Brick can give you the longest and most economical end wall service available today!

One quick comparison between the specifications above and those of *any* other end wall brick will tell you why open hearth operators all over the country specify Kaiser Periclase Chrome Brick:

1. Greatly increases end wall life when needed, or
2. Cuts costs with thinner walls, when end wall service is balanced.

This is because the PATENTED composition of Kaiser Periclase Chrome Brick assures you of less spalling, less swelling, greater resistance to abrasion and alteration by oxide and slag...

Let your Kaiser Chemicals sales engineer explain how you can take full advantage of Kaiser Periclase Chrome Brick in *your* open hearth. Contact the nearest sales office listed at right for immediate attention to your particular problem.



TO THOSE OF ANY OTHER END WALL BRICK!

More reasons why Kaiser Periclase Chrome Brick gives you better service:

1. Chromite content is the minimum amount (only 9.1% Cr_2O_3) necessary to provide thermal shock resistance. Lowering of chromite reduces swelling, thus minimizes end wall buckling.

2. A ceramic bond is formed *before* the chemical bond is destroyed.

3. No liquid phase in forming its ceramic bond. Volume stable.

4. Highest MgO content in end wall brick provides greater resistance to carryover erosion and iron oxide attack.

5. Lowest porosity minimizes alteration by resisting penetration of gases and impurities.

For more information call our nearest Sales Office: Kaiser Chemicals Division, 1924 Broadway, OAKLAND 12, Calif. . . . 3 Gateway Center, PITTSBURGH 22, Pa. . . . 518 Calumet Bldg., 5231 Hohman Avenue, HAMMOND, Indiana.

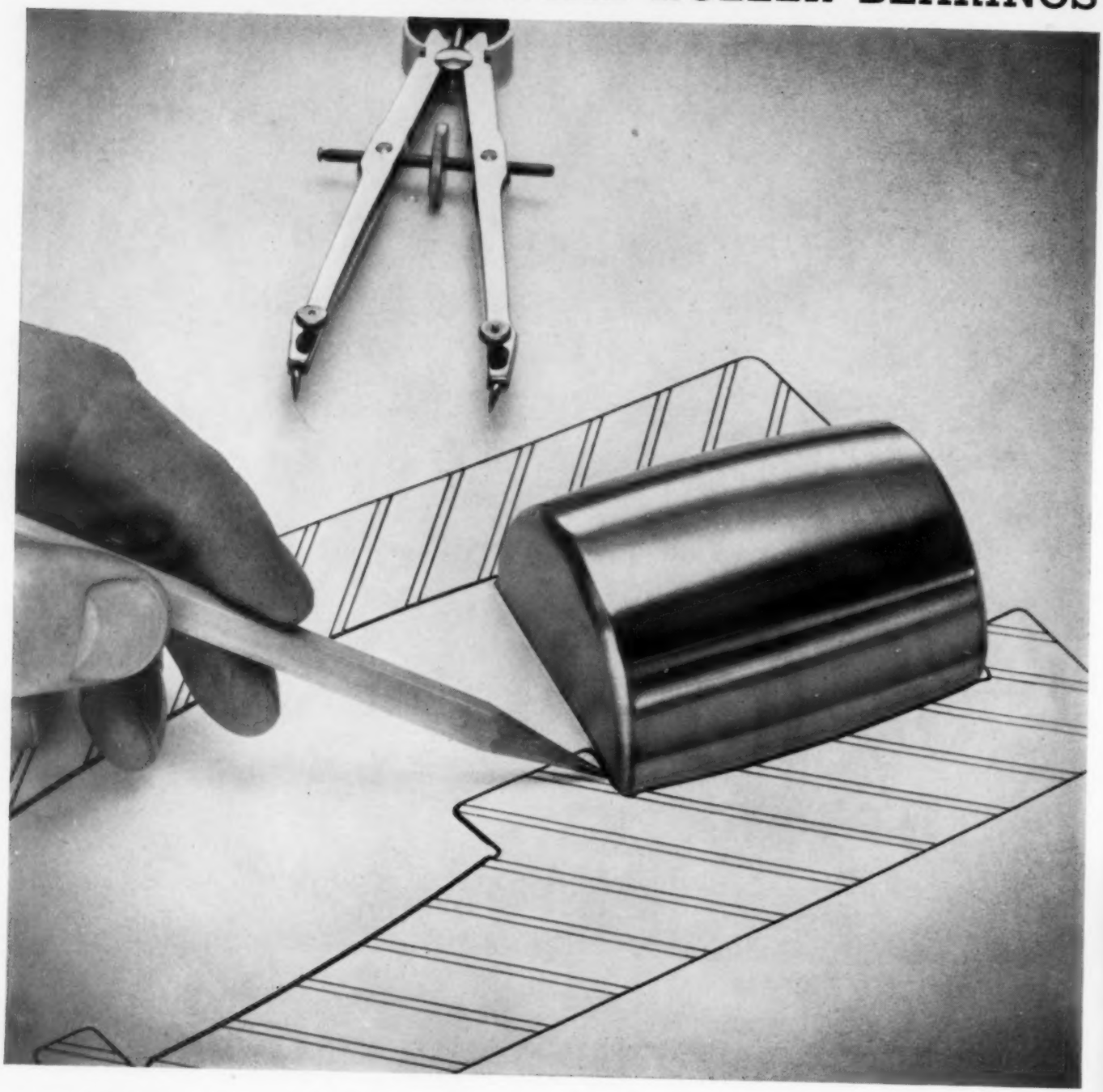
To obtain free copies of Kaiser Chemicals product literature write Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, OAKLAND 12, California, Dept. S6421.

Kaiser Chemicals

Pioneers in modern basic refactories

REFRACTORY BRICK AND RAMMING MATERIALS • CASTABLES & MORTARS • MAGNESITE • PERICLASE • DEADBURNED DOLOMITE

TORRINGTON *SPHERICAL ROLLER* BEARINGS



What a difference *conformity* makes!

TORRINGTON SPHERICAL ROLLER BEARINGS have the right degree of conformity between rollers and races and between roller ends and the center guide flange. "Skewing" is eliminated and rollers operate with a minimum of friction. This means even load distribution and long, low-maintenance service.

Because of their excellent performance in heavy-duty application, Torrington Spherical Roller Bearings have won wide acceptance in rock crushers, cranes, paper machinery, drilling rigs, presses—wherever high-load capacity is required under conditions of misalignment.

Torrington Spherical Roller Bearings are available with either straight or tapered bore, for shaft or adapter mounting. And Torrington engineers have wide experience in custom-building bearings for special applications. Whenever you need bearings, call on TORRINGTON.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866–1956

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

FOURTH OF A SERIES

Customer's Report

"Lee Wilson Single-Stack Annealing Furnaces boost our production per man hour by 60%"

"We've found the new Lee Wilson Single Stack Furnaces have raised production by 60 percent without increasing the number of operating personnel." This from the head of an annealing department that recently installed a complete Single Stack Annealing System.

The reasons: fuel input is doubled—as much as 5 million BTU per hour; improved convection systems distribute this high heat at tremendous velocities—thus the charge comes to heat faster. Forced cooling systems reduce the cooling down period—each base delivers 20 percent more productivity.

The Lee Wilson Single Stack System is the only modern system—specifically designed to meet the demands of tomorrow's production requirements.

Only Lee Wilson Furnaces Give You All These Advantages

1. GREATER FLEXIBILITY
2. MORE UNIFORM HEAT APPLICATION
3. IMPROVED CUSTOMER SERVICE
4. HIGHER PRODUCTION
5. BETTER LOAD FACTOR
6. MINIMUM PROCESS INVENTORY
7. REDUCED LABOR COST
8. BETTER OPERATING CONDITIONS
9. LOWER MAINTENANCE COST
10. REDUCED INSTALLATION COSTS

Lee Wilson* ENGINEERING COMPANY, INC.
20005 WEST LAKE ROAD • CLEVELAND 16, OHIO

SINGLE-STACK RADIANT TUBE ANNEALING FURNACES
MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES

9930

The trend is to single stack. One of the nation's largest annealing departments recently put into operation 24 Lee Wilson Single Stack Furnaces and 72 bases.

expanding mill standardizes on

To meet ever-increasing demands for specialized steel, an eastern mill has completed an extensive expansion program consisting of a new reversing cold mill and two auxiliary lines. Significantly, Allis-Chalmers control is utilized in all three operations.

Progressive mills are taking advantage of Allis-Chalmers experience in engineering, building and applying steel mill control — control that provides smooth, precision performance — control that affords maximum production and top quality with a minimum of outage time and maintenance. Get all the facts about Allis-Chalmers mill control. See your A-C representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

PICKLING LINE

The Allis-Chalmers control on this line provides an exceptionally wide speed range of more than 15 to 1. Power for the line comes from three separate m-g sets employing magnetic amplifiers for quick response. Complete synchronization between entry, processing and delivery sections permits continuous mill operation.

ANNEALING LINE

This control features power-type magnetic amplifier regulation for accurate control and low maintenance. Variable voltage power is obtained from a six-machine m-g set. Speed regulation of .5% assures constant strip speed and a resulting uniformity of high quality steel. Open-type control boards utilize Allis-Chalmers components especially designed for mill operation.

ALLIS-

ALLIS-CHALMERS

REVERSING MILL

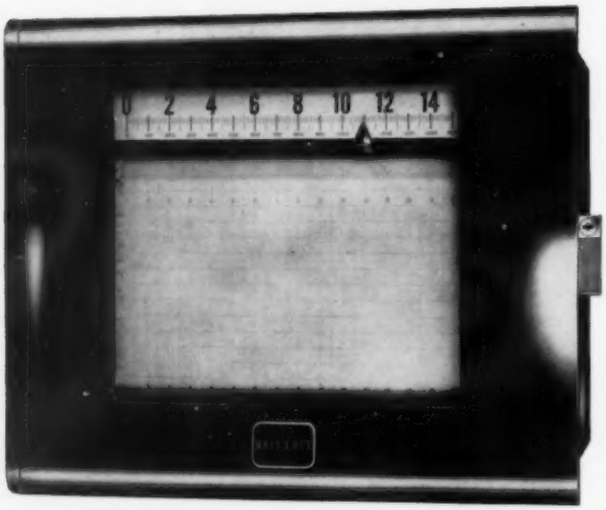
Critical percentage reduction of specialized steels rolled with this mill requires exacting control. Main mill voltage and reel tension circuits utilize new high-gain magnetic amplifier control. Because the magnetic amplifier is a static device, maintenance and necessity of replacement parts are reduced to a minimum. Fast arc-centering blowout on the dc contactors, shown on the control board, extends contact and chute life. Exceptional interchangeability of contactor and relay parts affords maximum convenience and economy.

A-C ALLIS-CHALMERS

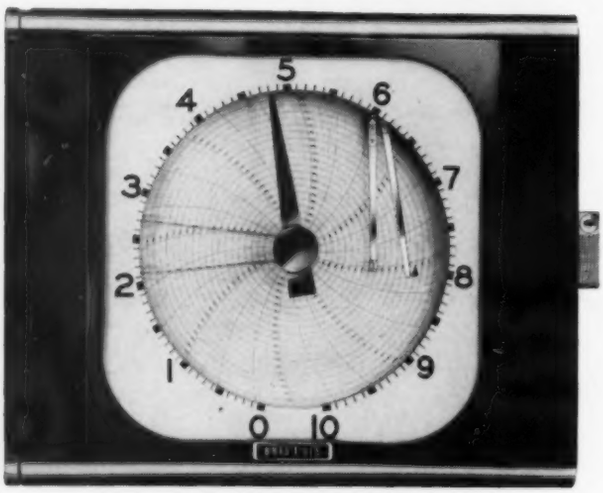
A-4971

CHALMERS

WHAT'S NEWS AT BRISTOL . . .



Three reasons temperature control is better with Bristol

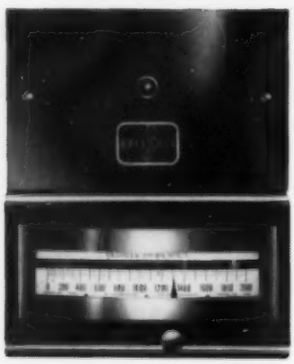


FIRST TWO REASONS are Bristol's Electronic Dynamaster Potentiometers with strip chart or round chart. Here's why:

No-Batt Continuous Standardization in these instruments eliminates need for dry cells. Result: No interruption in operation for standardization, no batteries to replace.

Recorders for every requirement – single-pen, two-pen, and multiple-record (up to 24 points)

Electric and pneumatic controllers for every furnace and oven control mode, including *electric controllers* for on-off, proportional-input, 3-position, proportional, proportional plus automatic reset, and time-program control; and *pneumatic controllers* for on-off, proportional, proportional plus reset, and proportional plus reset plus derivative control.



THIRD REASON: Bristol's Free-Vane® Electronic Pyrometer Controller. No relay chatter with this controller! Bristol's thyratron-operated relay puts a stop to that. Minute changes in temperature – less than 0.003" on scale – close or open the relay with positive trigger action. Available in thermocouple and radiation pyrometer controllers in ranges up to 4000F. New high-torque, rugged millivoltmeter gives greater accuracy and a sensitivity of 15 ohms per millivolt. Separate plug-in control units, variety of control modes available.

Get the whole story on these three rugged Bristol Furnace and Oven Controls. Write for free 48-page Bulletin P1260 today. It contains specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn.
5.40

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

TRADE MARK BRISTOL'S REG U.S. PAT OFFICE

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Not just for your special-purpose motors . . .

General-purpose motors also deserve

NATIONAL
TRADE-MARK

Carbon Brushes

Get the right commutating ability for the particular type of motor and the given service conditions

For regular duty a handsome choice of grades with proven dependability...

N-4 SA-45 SA-35 255

For unusual duty light or severe, many specialized grades including...

SA-4548 SA-3538 258
SA-4542 SA-3532

Whether it's 5 or 250 h.p.....light or heavy duty...motor or generator...the right brush pays big dividends in efficient output and long equipment life. Whenever you have a problem concerned with brush performance and commutation, feel free to call on NATIONAL CARBON for specialized advice.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation
NATIONAL CARBON COMPANY • A Division of Union Carbide and Carbon Corporation • 30 East 42nd Street, New York 17, N. Y.
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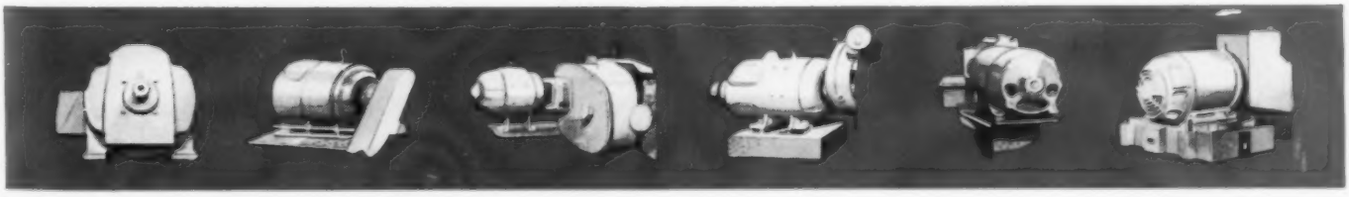


From one source . . . any instrumentation you need

When it comes to measurement and control, every industrial process is different. Each demands its own combination of accuracy, economy, instrument ranges and all the numerous other characteristics that are peculiar to the individual application.

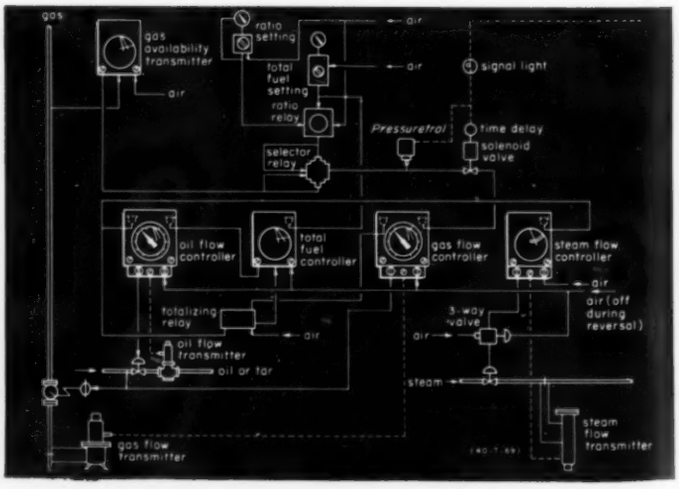
No single instrument and its accessories could possibly fit every process. So Honeywell makes a broad variety of measuring and controlling equipment that spreads across a tremendous range of applications.

The advantages are two-fold. First, you can get all the instrumentation your process requires from a single source, so there is undivided responsibility for the complete installation. And second, you are assured that the equipment selected for your process is recommended without bias . . . neither over-sells nor under-equips . . . needs no stretching, squeezing or compromising to fit it to its assignment.

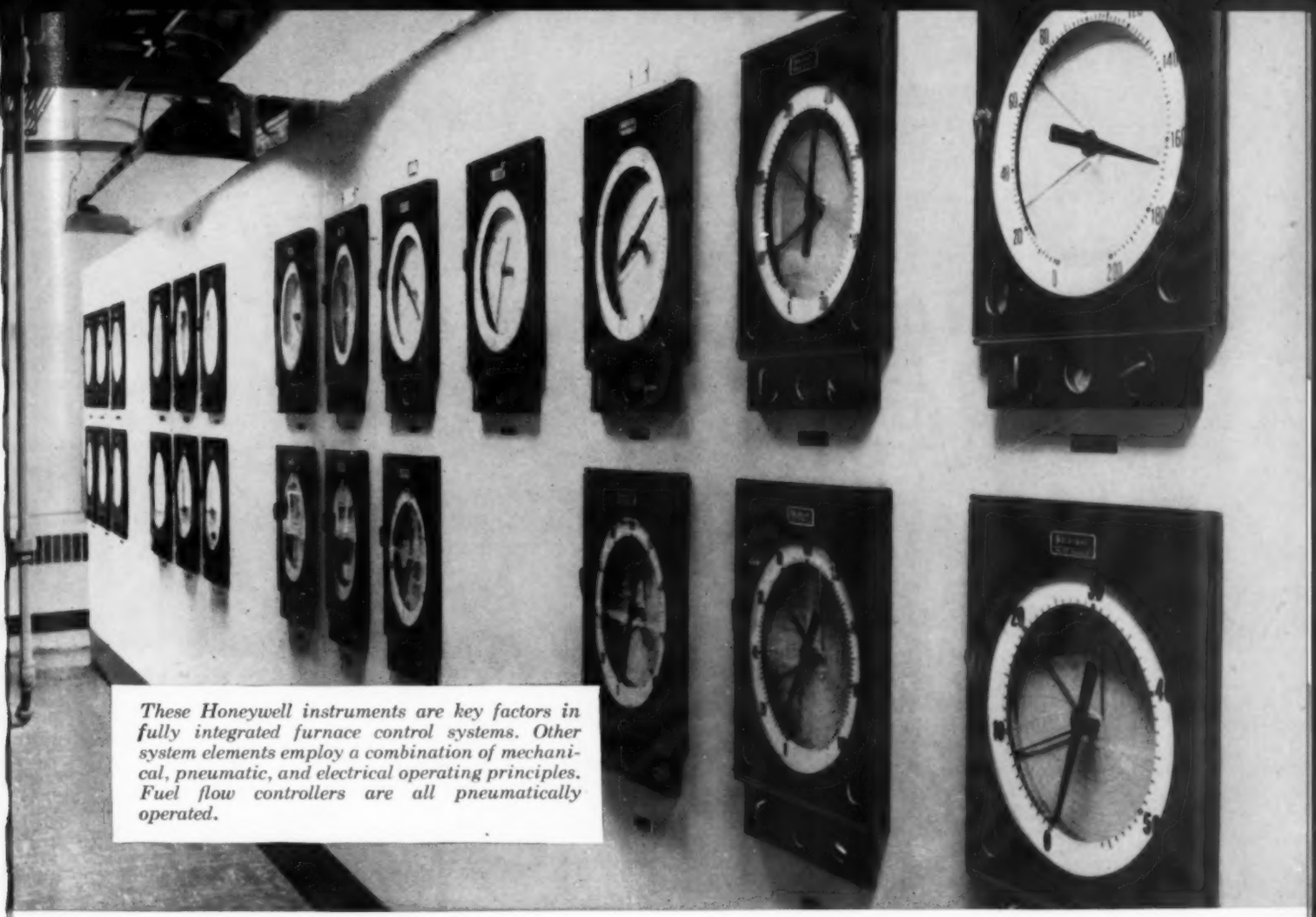
This versatile family includes *ElectroniK* indicators, recorders and controllers in circular and strip chart models, applicable to temperature, pressure, pH, power and dozens of other variables; square root flow meters for control applications; evenly graduated flow meters for cost accounting; thermometers, pressure gages and liquid level meters; *Pyr-O-Vane* millivoltmeter controllers. Especially useful for graphic panels are the *Tel-O-Set* miniature indicators, recorders and controllers. Electric and pneumatic control systems range from the simplest to the most complex, including automatic program controls and complete systems developed for particular processes.

Working with these instruments is a full choice of primary elements . . . thermocouples, *Radiamatic* radiation elements, pressure-type and electrical resistance thermal systems, flow meter bodies, pH cells and many others. For final control elements, you can choose from a wide range of electric motorized and diaphragm operated valves. To complete the picture, there are more than 7000 non-indicating devices for controlling temperature, pressure, vacuum, liquid level and humidity . . . an unmatched variety of instrumentation made by the world's largest manufacturer of control equipment.

Honeywell-engineered reheating furnace control system . . .



Control system for triple-fired, three-zone slab reheating furnace.



These Honeywell instruments are key factors in fully integrated furnace control systems. Other system elements employ a combination of mechanical, pneumatic, and electrical operating principles. Fuel flow controllers are all pneumatically operated.

puts byproduct gas to work

A large Eastern steel mill was faced with the problem of how to economically use its large quantities of byproduct gas fuels. A Honeywell-engineered control system provided the economical solution. The system puts byproduct gas fuel to work on the basis of its availability, automatically adjusting the combustion system as required. It adds the right amount of oil fuel to gas to make up the total fuel demand. And it maintains correct fuel-air ratios, automatically, under all firing conditions.

Manual control of furnaces was exceedingly difficult for two reasons. First, much of the gas was fed to multiple-fuel reheating furnaces, and surplus gas often varied widely and rapidly in availability. And second, fuel oil was used to make up the difference between furnace fuel demand and available byproduct gas fuel. Simultaneous balancing of the quantity of each fuel was needed to satisfy temperature and load demands of reheating furnaces.

Time that used to be spent coping with fuel problems now is concentrated on furnace operation and product quality. Personnel training and trouble-shooting have been simplified by the use of instruments of familiar design and construction. Maintenance of the complete interlocked control system, even in this steel mill environment, is no greater than that required for single instruments.

In your own plant, instrumentation by Honeywell can lead directly to important economies and upgraded product quality. Your nearby Honeywell sales engineer can give you the facts and figures . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

NOW GENERAL ELECTRIC LIMITAMP* STARTERS OFFER EXTRA SPACE SAVINGS BY ELIMINATING FUSE CABINET

General Electric Limitamp starters now offer you greater savings of valuable floor space . . . savings made possible by eliminating the need for an extra fuse cabinet. Previously, starters controlling high-horsepower motors required *six* double-banks of fuses, making necessary an extra fuse cabinet.

Now, through use of higher-capacity Type EJ-2 fuses, G-E Limitamp starters of this type will be delivered to you with *three* double-banks of fuses, thereby eliminating need for the extra cabinet. This single new feature of G.E.'s high-voltage motor control saves over five square feet of space.

HERE ARE MORE FEATURES ONLY LIMITAMP CONTROL OFFERS

Savings of floor space is but one benefit of General Electric Limitamp control. There are many more. For instance:

- easy installation and connection, made possible with roll-out contactor unit and centrally located bus compartment
- increased personnel safety, provided by three-phase disconnect switch
- flexible arrangement of units and added space savings with all connections made from front
- complete range of modifications to meet any installation requirement

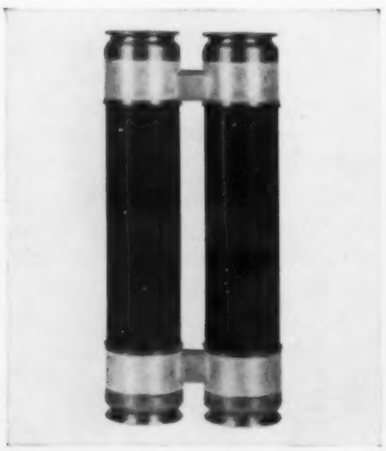
TAKE ADVANTAGE OF THESE BENEFITS NOW

Don't be satisfied with "old-fashioned" high-voltage motor control: Specify General Electric's Limitamp control—*leader in design and performance.* Contact your G-E Apparatus Sales representative today, or write Section 783-1, General Electric Company, Schenectady, New York. *Industry Control Dept., Roanoke, Virginia.*

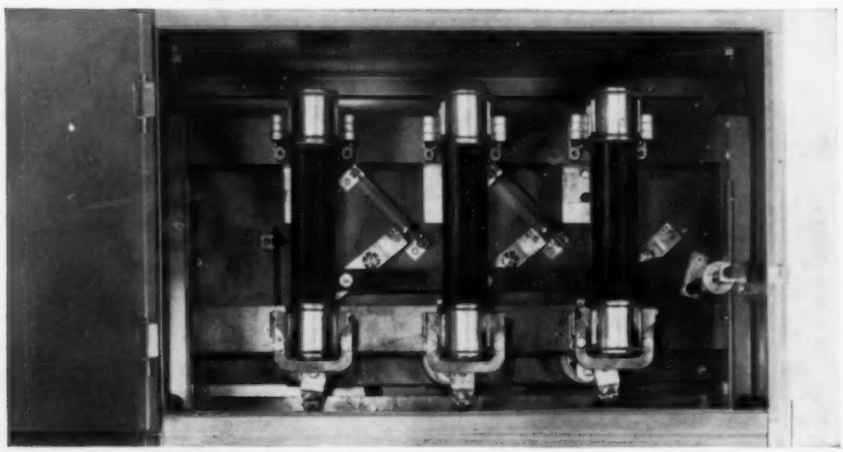
*Reg. Trade-mark of General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC



HIGHER CAPACITY of EJ-2 fuses eliminates need for extra fuse cabinet.



ONLY HALF AS MANY FUSES—three double banks—are now used in the General Electric Limitamp starters controlling motors of 700 horsepower and above.

. . LEADER IN DESIGN AND PERFORMANCE

CLAMP DOWN-

on excess inventory in your Annealing Department

● If you are caught in a "squeeze" for additional operating capital, you might look to your annealing department and ask yourself this question—"Do we have too much money tied up in process inventory?"

If you are operating old style multiple-stack furnaces, your process inventory is running from 50 to 80 per cent higher than the requirements of a single stack installation. A recent study proves that a complete installation of Lee Wilson single stack furnaces can "clamp down" on funds required for process inventory by several hundred thousand dollars.

Let a Lee Wilson sales engineer prove this to you at your convenience.

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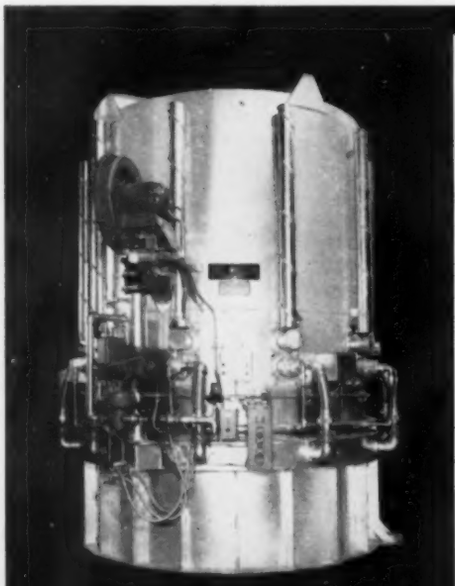

Lee Wilson* **ENGINEERING COMPANY, INC.**

20005 WEST LAKE ROAD • CLEVELAND 16, OHIO

SINGLE-STACK RADIANT TUBE ANNEALING FURNACES

MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES

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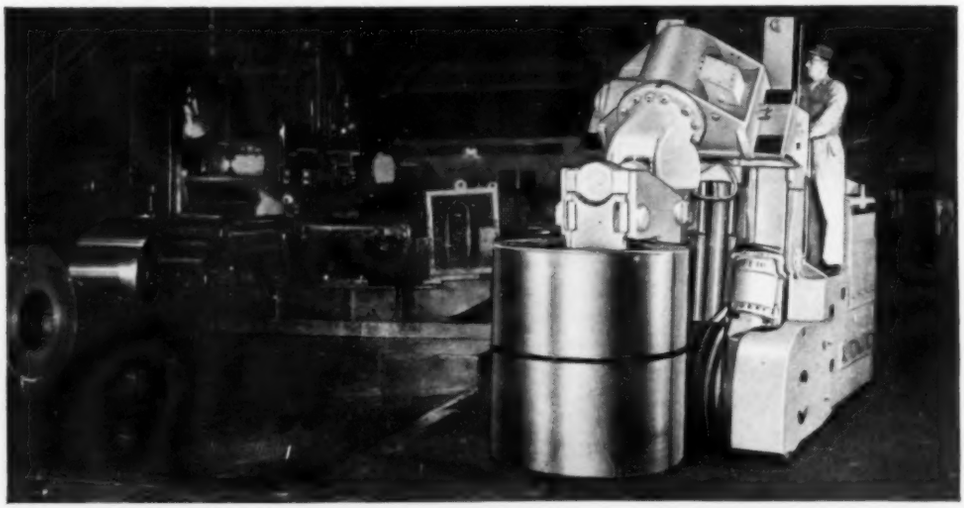
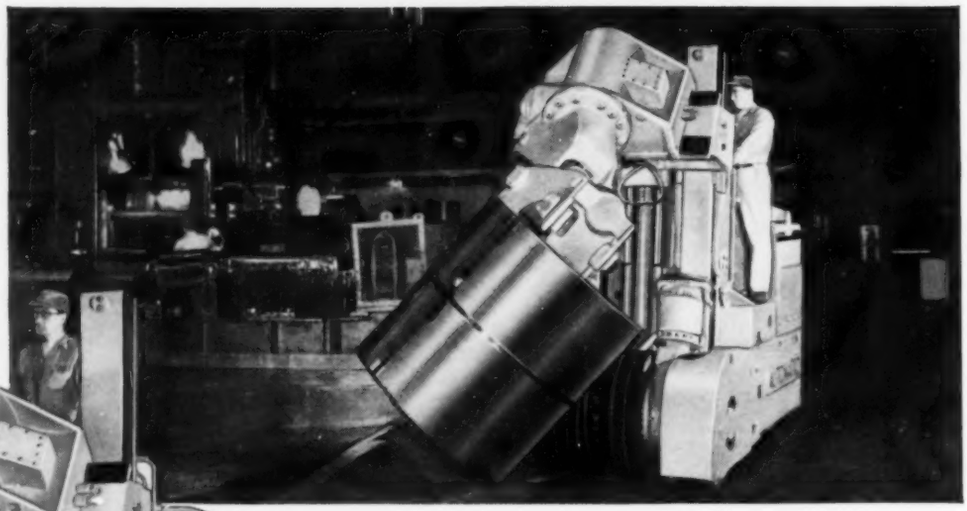


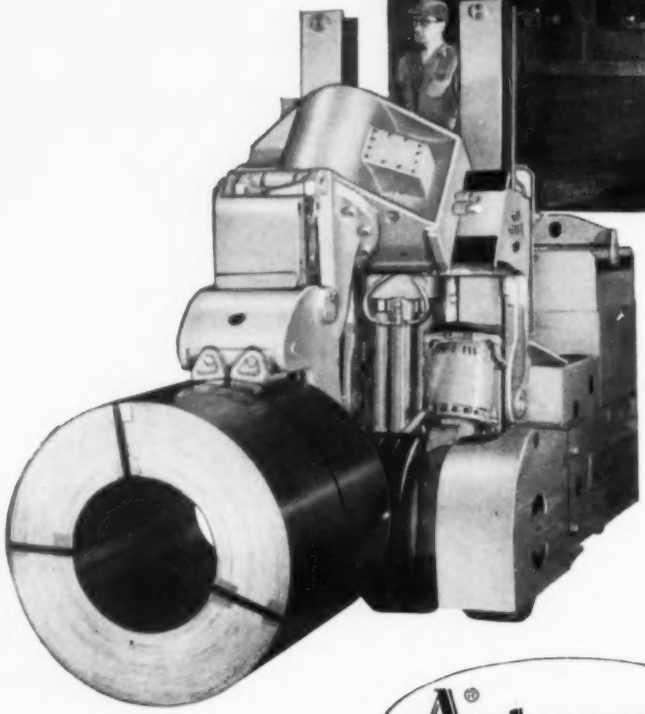
1.

Picks up coil in vertical position and rotates to horizontal or vice versa... handles up to 60,000 lb. coil.



2.

Holds coil securely throughout rotation...prevents telescoping...no distortion, no damage to coil ends.



3.

Transports coil in any position; can be replaced by forks or ram for other uses.

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Another important "first" for Automatic engineering...this attachment eliminates the necessity for separate up-ending units in handling steel coils weighing up to 60,000 lbs. Flexibility in handling and storage is substantially improved and usefulness of the heavy duty ram truck is correspondingly increased. The coil is held securely, at any stage of rotation with a minimum of pressure, eliminating damage to coils.

This unit is now available on the new Automatic HR Series electric trucks or as an attachment for any Automatic truck of suitable design and capacity. Write today for further information.

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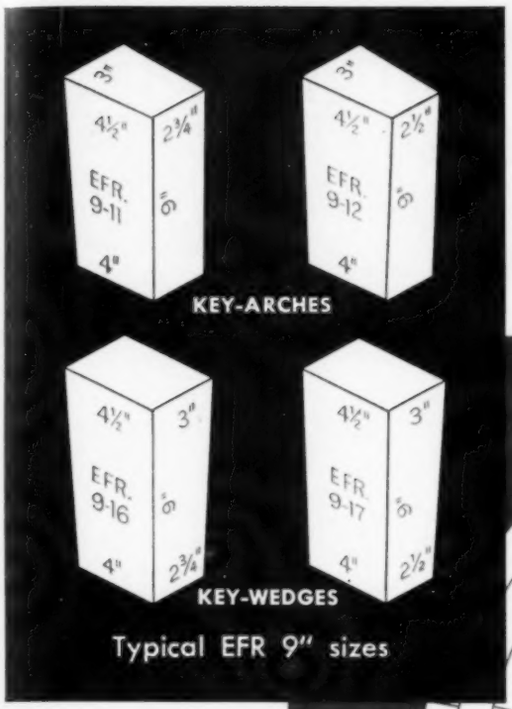
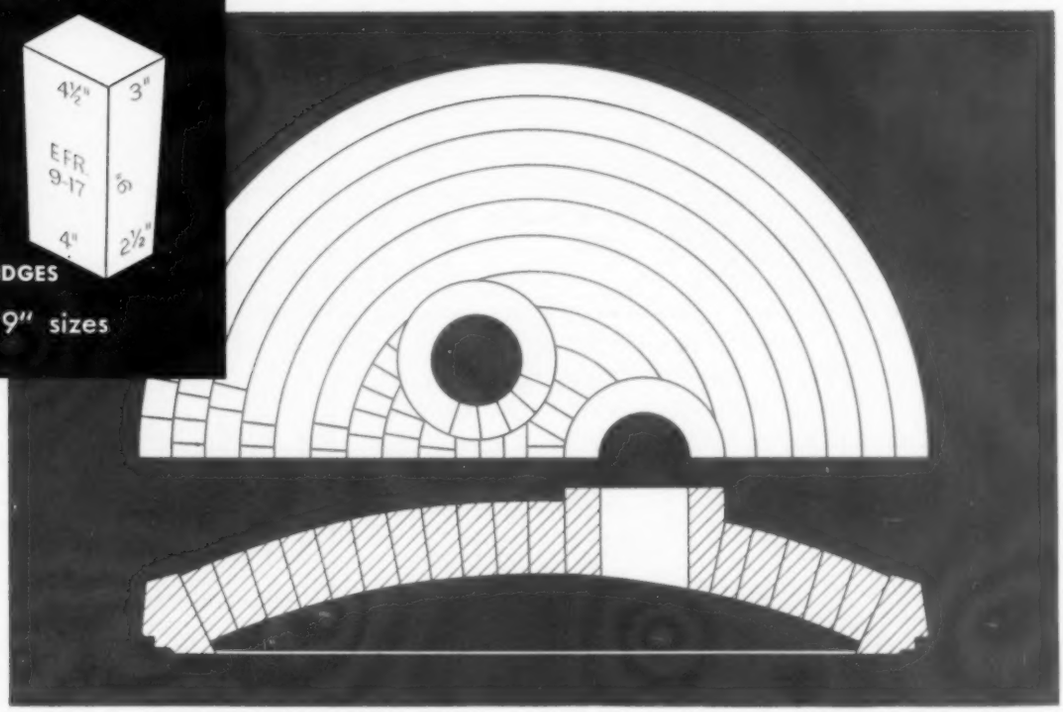
For electric furnace roofs

Harbison-Walker EFR design

provides important benefits





Harbison-Walker EFR (electric furnace roof) brick are modified 9″ key-arches and key-wedges, designed for use in combination with a large proportion of standard 9 x 4½ x 3″ sizes in the construction of roofs of any diameter and rise.

The use of these EFR shapes insures a close fit of the brick and roof construction of best workmanship.

The number of different sizes required for building a roof with the aid of the EFR brick is greatly reduced for some designs.

Bricklaying is simplified and much time is saved when EFR brick are used.

EFR brick are power pressed by which method of forming all of the most desirable physical properties are secured.

Roofs built of smaller brick units in preference to large special shapes generally prove to be more serviceable. The smaller sizes are more resistant to thermal shock.

The EFR shapes cost less than large special shapes and since they are used with standard 9″ sizes in predominance, the overall cost is considerably reduced.

H-W High Alumina Castable and Korundal Ramming Mix sometimes are used to advantage as a monolith to facilitate easy fitting in the center section.

The EFR brick, together with the standard 9″ sizes needed for complete roofs, are furnished in the types and classes of refractories best suited for the various operating conditions. For example, they are made in the following brands: STAR and VEGA silica brick; H-W MULLITE; KORUNDAL; and various Harbison-Walker superduty brands, such as ALAMO and H-W SUPER SAVAGE.

The combination of quality, H-W Technical Service and balanced selection based on availability of all types and classes of refractories from one source, provides maximum economy.

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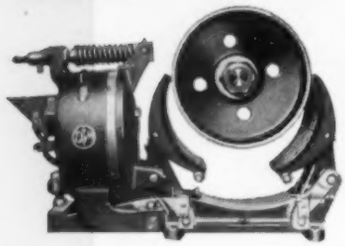

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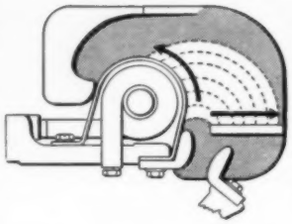

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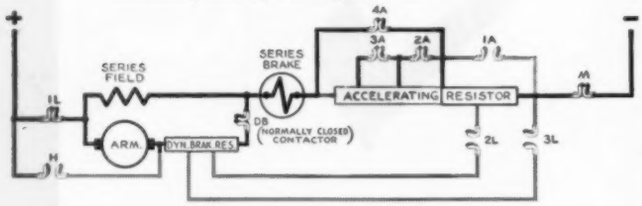

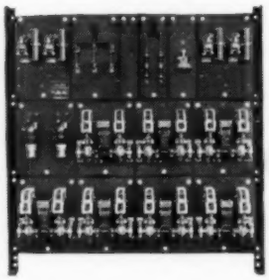

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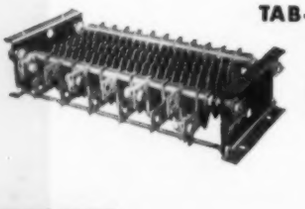

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By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period May 1, 1956 through May 22, 1956 . . . .

PRODUCTION OF POWDERED IRON

▲ U. S. 2,744,002, issued May 1, 1956 to Henry L. Crowley and assigned to Republic Steel Corp., describes a process for producing iron powder having improved physical properties.

The usual process of reducing iron oxide with hydrogen is a "subtractive process," in that reduction takes place by direct removal of oxygen atoms from the iron oxide crystal lattice. Such a process results in a structure with the microscopic appearance of having had portions of it gouged out. Iron powder of this type is relatively difficult to mold to a given density, and results in relatively low tensile strengths.

The present invention utilizes an "additive process." The iron oxide is first reduced to FeO with hydrogen, and is then converted to $FeCl_2$ vapor by reaction with HCl. The $FeCl_2$ vapor is then reduced further to metallic iron, depositing on crystals of iron already formed, causing them to grow larger. This iron is characterized by dense crystalline structure. Furthermore, the size and shape of the particles produced is independent of the shape of the pulverized oxide particles.

The reactions all take place simultaneously in a mixture of hydrogen and hydrogen chloride, the $FeCl_2$ being merely an intermediate in the reduction process.

As an example of the improved physical properties, tensile strengths increased from 18,300 to 20,600 psi.

ACCELERATING THE FINAL STAGE OF THE DIRECT REDUCTION OF IRON OXIDE

▲ U. S. 2,744,005, issued May 1, 1956 to Ford L. Coolman and Marion E. Graham, assigned to Republic Steel Corp., describes a process for accelerating the final portion of the direct reduction of iron oxide to iron below its melting point, with hydrogen as the reducing agent.

After about 80 per cent of the oxygen has been removed, the remainder is removed in a separate process by exposure of the material to a reducing zone maintained at about 700 C, containing hydrogen and about 1 per cent hydrogen chloride by volume. $FeCl_2$ is postulated as an intermediate in the process. The increased speed of reaction is attributed to the more rapid rate of reaction of FeO with HCl (which is a neutralization reaction) than with hydrogen. Thus the HCl acts as a catalyst.

INTRODUCTION OF AIR TO OIL BURNERS IN OPEN HEARTH FURNACES

▲ U.S. 2,744,744, issued May 8, 1956 to James L. Hartney and assigned to United States Steel Corp., describes a method of atomizing oil in burners with air, increasing the furnace efficiency over that obtained with steam as the atomizing fluid.

Preheated compressed air is directed to either burner (or set of burners) in an open hearth furnace, continuous flow of air being maintained through the burner during changeover periods so as to prevent its overheating.

DIRECT PRODUCTION OF IRON OR STEEL IN AN ELECTRIC FURNACE

▲ U.S. 2,744,820, issued May 8, 1956 to Friedrich Kocks, describes a process for the direct reduction of iron ore with liquified carbon-rich molten iron in an electric furnace.

In order to make the process practical, it is necessary to continually add carbon to the melt, since otherwise the reduction soon ceases. This is accomplished in the present invention by continually lowering carbon electrodes into the bath.

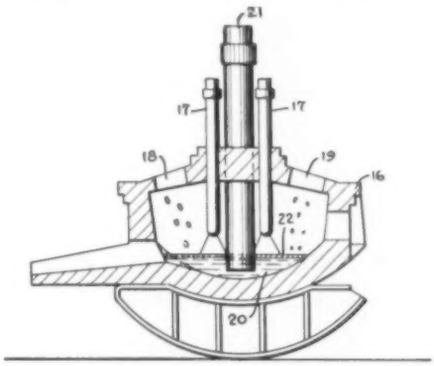


Figure 1

As shown in Figure 1, the furnace 16 is provided with carbon electrodes 17 providing the necessary processing heat. The iron ore is introduced through opening 18 and the flux through opening 19 in the ceiling of

the furnace at a rate which enables the reduction of the ore and the solution of the reduced metal in the carbon-rich iron melt 20. An adjustable massive carbon electrode 21, which reaches into the iron bath supplies the carbon required for the reduction. If the entering rate of the electrode 21 into the bath 20, and the supply of ore and flux is properly proportioned, an extremely simple process results.

The process can be made essentially continuous, if desired, in which case iron or steel having a predetermined percentage of carbon is periodically tapped. The electrode 21 is lifted temporarily from the furnace prior to the tapping in order to permit the carbon content to decrease to the desired level.

An advantage of the process is that it is independent of the physical or chemical quality of the carbon.

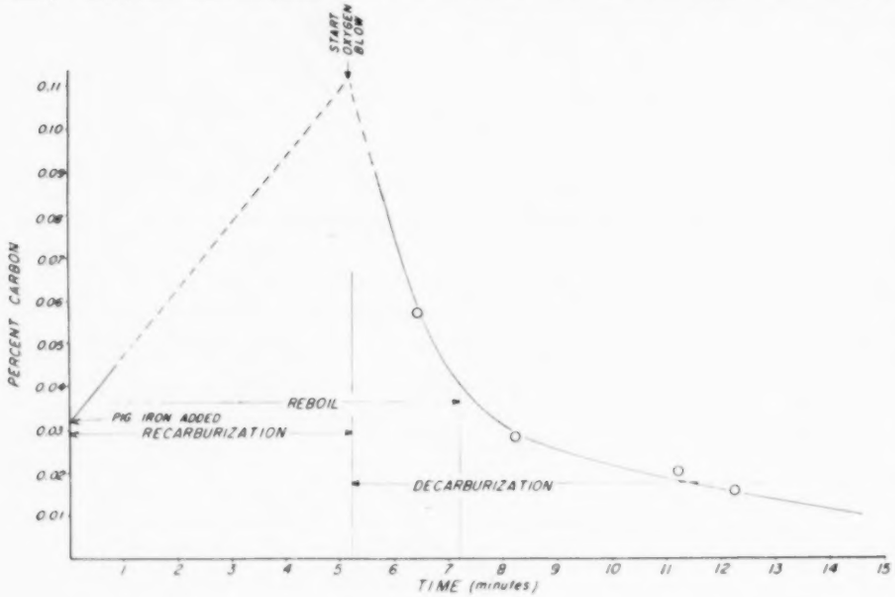


Figure 2

METHOD FOR MAKING LOW CARBON 18-8 TYPE HEATS

▲ U. S. 2,745,731, issued May 15, 1956 to Garland W. Reese, Jr., and George E. Schmidt, assigned to Allegheny Ludlum Steel Corp., describes a method of making low carbon 18-8 type stainless steel, thus overcoming the usual "sensitization" of these steels which is attributable to precipitation of chromium carbide at elevated temperatures.

A charge of low-phosphorus carbon scrap metal which is devoid of oxidizable elements such as chromium, manganese, silicon, and aluminum, but which contains predetermined amounts of sulphur, phosphorus, and copper, is charged into an electric arc furnace of the carbon or graphite electrode type together with slag-forming material such as burned lime and with most of the nickel and molybdenum in the form of oxides. This charge is melted through the action of the carbon arcs to form a molten metal bath. At this point, the carbon content is slightly above 0.03 per cent, the oxides having reduced most of the carbon. About 80 per cent of the slag is then drawn off. The carbon content of the molten metal bath is then adjusted through the use of either ore additions or gaseous oxygen or both. After the carbon content is adjusted to the predetermined low level, the additional alloying elements are added. The molten metal bath is then refined to obtain the desired chemical analysis, and is then tapped.

Ordinarily, when the oxygen is blown into the electric furnace, extremely large volumes have been required in order to bring the carbon content below 0.03 per cent, considerable amounts of iron being preferentially oxidized into the slag. In addition, this raises the temperature of the bath as high as 3200 F, thus shortening the life of the refractory.

These problems are avoided in the present invention by adding to the molten bath 2 to 6 per cent by weight of pig iron containing about 4 per cent carbon and 6 per cent silicon. As shown in Figure 2, this increases the carbon content of the bath from a value slightly in excess of 0.03 per cent up to about 0.11 per cent, and causes a violent reboiling action. Gaseous oxygen is then injected at a predetermined rate for a period of 3 to 8 minutes, reducing the carbon content below 0.020 per cent. It is believed that the reboiling action assists the reaction of oxygen and carbon.

The patent gives complete details as to the method of operation, along with a number of examples.

SEPARATION OF NICKEL FROM IRON ORES

▲ U. S. 2,746,856, issued May 22, 1956 to Edgar B. Mancke and assigned to Bethlehem Steel Co., describes a method of separating nickel from iron ores such as Cuban Mayari ores.

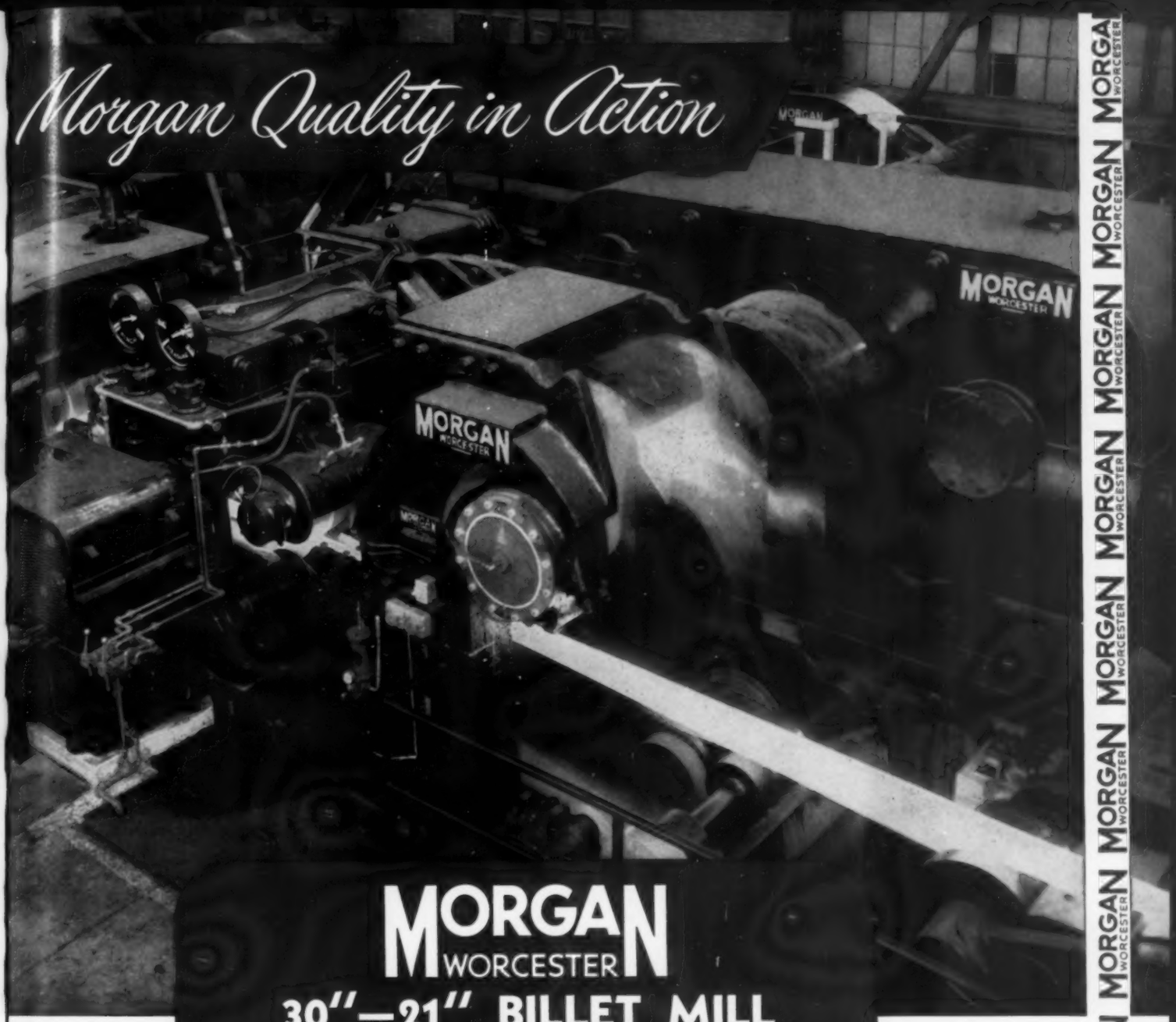
The invention consists of mixing the ore with enough nitric acid to react with the nickel and cobalt content of the ore and dissolving these substances at elevated temperature and pressure, the iron remaining in the solid phase as an oxide.

The invention is based on the discovery that nickel and cobalt nitrates are stable in aqueous solution, while ferric nitrate is not. When an aqueous solution of ferric nitrate and nitric acid is autoclaved at 310 to 650 F, the ferric nitrate forms nitric acid which remains in solution and ferric oxide which is precipitated.

MANUFACTURE OF FERROMANGANESE FROM STEEL MILL SLAGS AND LOW GRADE MANGANESE ORES

▲ U. S. 2,746,857, issued May 22, 1956 to Edwin C. Wright, describes a process of producing high-manganese ferromanganese from waste steel mill slags and low grade natural ores containing 2 to 20 per cent manganese. This process makes it possible for the steel industry to produce all the manganese needed in the finishing of steel without importation, largely from its own waste slags.

The process consists of the following steps: (1) preparing a blast furnace charge containing slag and low-grade ore, together with the other constituents of a normal blast furnace charge; (2) smelting the charge to recover in the molten pig iron all the manganese; (3) transferring the molten pig iron containing about 5 per cent Mn, to an acid-lined vessel



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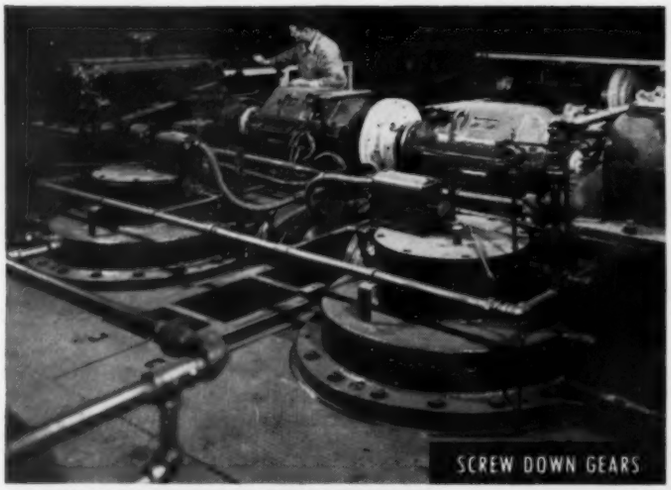

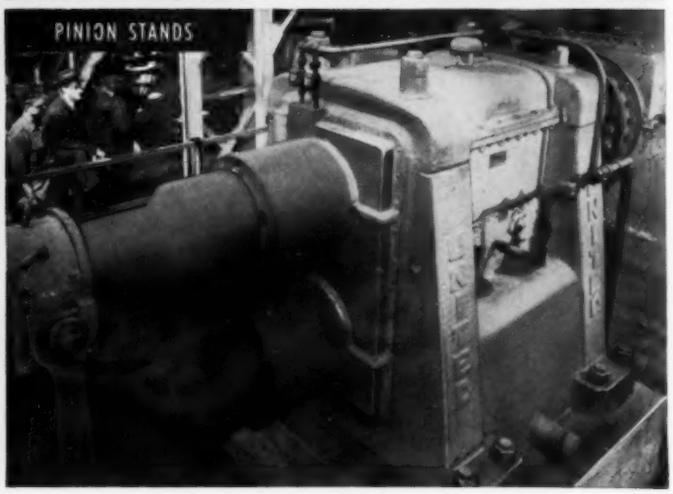

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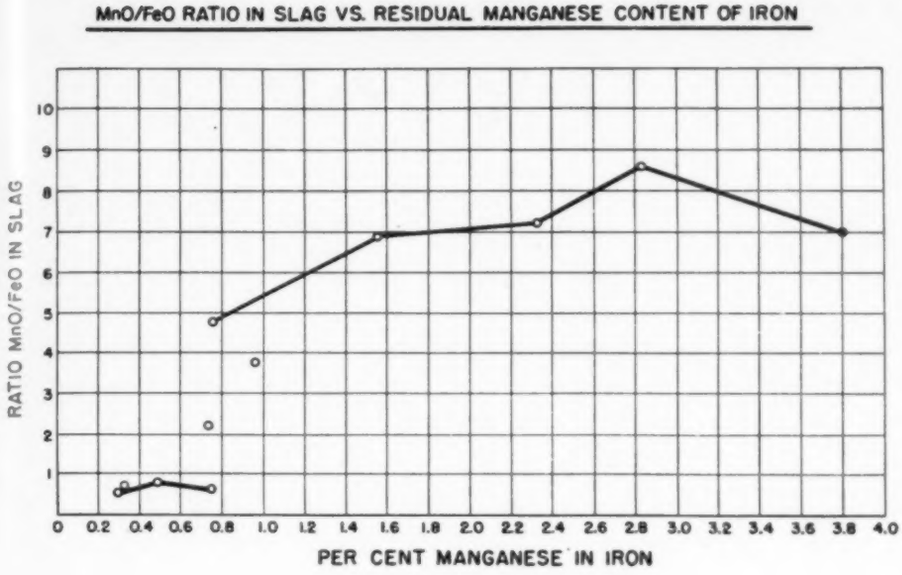

MnO/FeO RATIO IN SLAG VS. RESIDUAL MANGANESE CONTENT OF IRON
RATIO MnO/FeO IN SLAG
PER CENT MANGANESE IN IRON
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
1 2 3 4 5 6 7 8 9 10

Figure 3

and introducing gaseous oxygen or air into the vessel to form an oxidic slag which is rich in MnO and SiO_2; (4) removing the manganese-rich slag from the pig iron before reducing the manganese content of the molten pig iron below 0.8 per cent; (5) then charging into a carbon or graphite lined smelting furnace the manganese-rich slag and sufficient carbon to reduce the iron and manganese content of the slag, together with two parts of CaO per part of SiO_2 in the slag; (6) heating the mixture to 1600 to 1700 C, thus reducing most of the MnO and FeO of the slag to a ferromanganese alloy. Most of the silica is held in the slag as dicalcium silicate.

As shown in Figure 3, the critical point in the process is limiting the amount of air or oxygen used in the blowing step, so that at least 0.8 per cent manganese remains in the pig iron when the slag is removed. If this is not done, the ratio of manganese to iron in the slag is very low.

METHOD OF TINPLATING

▲ U. S. 2,746,884, issued May 22, 1956 to Ludwig Rosenstein and Manuel H. Gorin provides a new type of oil composition for use in hot-dip tinning of steel in place of palm oil as a bath over the molten tin.

The new oil is a resin-modified non-drying vegetable oil such as cotton-seed oil, tallow, or rice-bran oil. The resin used may be gum rosin, wood rosin, ester gum, liquid rosin, hydrogenated rosin, certain tall oil esters, etc. The resin and oil are heated together until homogenous.

Compositions of this type were tested for "activity" in tinplating at 290 to 300 C. Palm oil remained active for 10 minutes. Rice-bran oil alone remained active for 6 minutes. Rice-bran oil compounded with 20 per cent rosin remained active 16 minutes.

WASTE PICKLE LIQUOR DISPOSAL

▲ U. S. 2,746,920, and 2,746,921, issued May 22, 1956 to John M. Wunderley, describe a process and apparatus for disposing of waste pickle liquor.

The spent pickle liquor is slurried with granulated basic blast furnace slag. The slag neutralizes the acid content of the waste pickle liquor and the liquid content of the liquor is entirely absorbed by the slag. Ten to twelve pounds of granulated dry slag are mixed with each gallon of waste pickle liquor. This changes the pH of the liquor within 5 minutes from 1 to 6 or 7. The product is damp, but may be shoveled or carted away and dumped without any liquid draining away.

The apparatus used is shown in Figures 4 and 5. The numeral 1 designates a mixing cylinder which rotates on rollers 2. The waste pickle liquor is stored in tank 7, from which it flows by gravity to the mixing cylinder. The rate of flow of liquor is controlled by valve 11.

Granulated slag is stored in a bin 12 having a top opening 13 and a

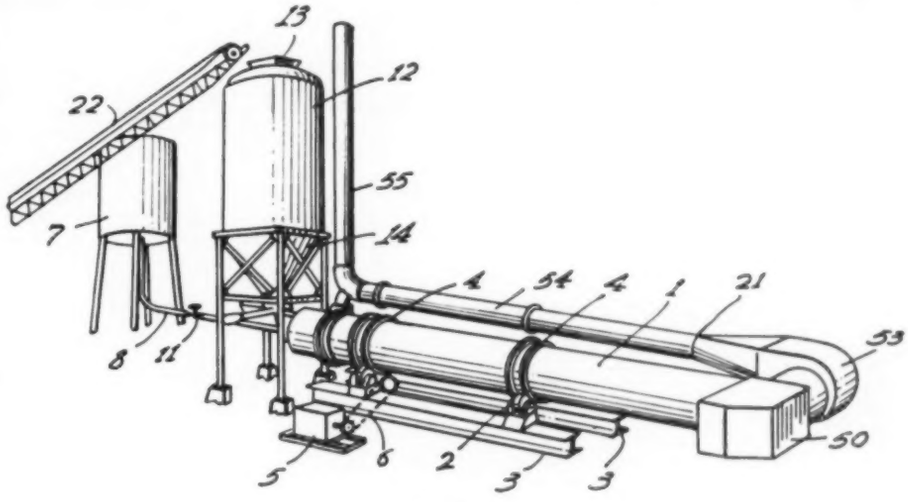
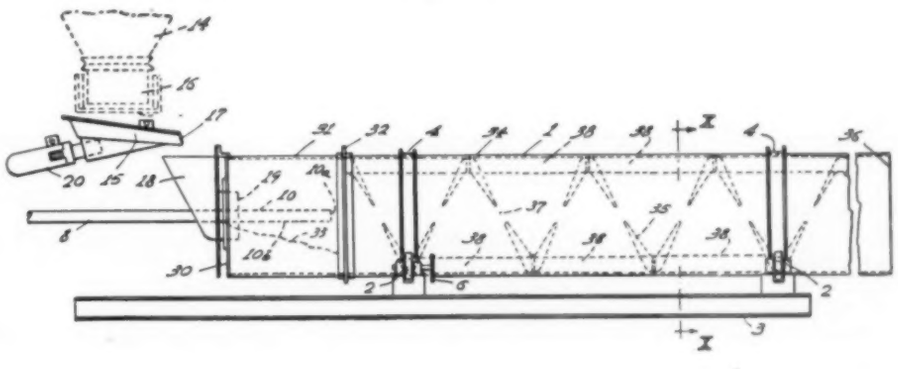


Figure 4

Figure 5



discharging hopper 14 at the bottom. The bottom of the hopper is positioned directly above an inclined chute 15 onto which slag falls. The rate of flow of slag is regulated by an electrical vibrating unit 20 which vibrates the chute.

The interior of the apparatus is ventilated by a unit 21, through which steam and fumes generated within the cylinder are discharged. Exhaust of steam and fumes causes fresh air to be drawn into the cylinder 1 through the opening at its charging end.

Slag drops from the end of the chute 15 into a charging hopper 18, and waste pickle liquor enters through pipe 8 which has perforations at the bottom for spraying the liquor onto the slag. After the initial contacting in the first chamber 31 of the mixing cylinder, the slag and entrained liquor move to the final mixing chamber 34. This chamber contains a spiral mixing vane 35 which extends along the inner surface of the cylinder. The vane is interrupted at intervals 37, to avoid moving the mixture too rapidly through the apparatus. A number of baffle plates 38 increase the mixing action.

The final product drops out of the bottom of the housing 50.

According to the inventor, very little corrosion is encountered, because a coating of slag or products of the reaction forms on the metal. Only the tank 7 and pipe 8 are rubber-lined.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,743,492	5/ 1/56	Apparatus for controlling the flow of molten metal	Allegheny Ludlum Steel Corp.
2,743,493	5/ 1/56	Ingot mold insert mat	William E. Schmertz and Harrison D. Sterick
2,743,692	5/ 1/56	Strip welding machine	Armco Steel Corp.
2,743,700	5/ 1/56	Continuous metal production and continuous gas plating	The Commonwealth Engineering Co. of Ohio
2,744,004	5/ 1/56	Lowering the carbon content of high carbon ferrochromium	Chromium Mining & Smelting Corp.
2,744,009	5/ 1/56	Ni-Cr hard facing alloys	Crucible Steel Co. of America
2,744,040	5/ 1/56	Preparing iron powder for magnetic cores	General Aniline & Film Corp.
2,744,152	5/ 1/56	Electric furnace with carbonaceous atmosphere	General Electric Co.
2,744,305	5/ 8/56	Bucket attachment for ingot strippers	Ervin A. Drill
2,744,479	5/ 8/56	Soaking pit curb	Amsler Morton Corp.
2,744,687	5/ 8/56	Furnace pressure control	Surface Combustion Corp.
2,744,692	5/ 8/56	Automatic stop mechanism for wire drawing machine	United States Steel Corp.
2,744,743	5/ 8/56	Pellet indurating process	Erie Mining Co.
2,744,745	5/ 8/56	Sealed annealing apparatus	William E. Engelhard
2,744,821	5/ 8/56	Iron base high temperature alloy	General Electric Co.
2,744,858	5/ 8/56	Floating resilient sealing frame for coke oven doors	Koppers Co., Inc.
2,745,280	5/15/56	Apparatus for supporting sheet-metal specimens during a test	United States Steel Corp.
2,745,663	5/15/56	Strip supporting device	United States Steel Corp.
2,745,730	5/15/56	Reducing manganese ores	Pickands Mather & Co.
2,745,732-4 & 2,745,737	5/15/56	Reducing ores by a particular fuel combustion mixture	Ford Motor Co.
2,745,738-9	5/15/56	Steel alloy blanks for glass-to-metal seal	United States Steel Corp.
2,745,776	5/15/56	Restoring hardenability of boron-containing steel	United States Steel Corp.
2,746,511	5/22/56	Apparatus for unwinding coils	Donovan Steel Pickling Co.
2,746,610-11	5/22/56	Door-handling mechanism for the doors of horizontal coke-ovens	Koppers Co., Inc.
2,746,740	5/22/56	Cycle annealing furnace	Surface Combustion Corp.
2,746,743 & 2,746,858	5/22/56	Cupola furnace provided with means to produce a gaseous curtain in its opening	Claude B. Schneible Co., Inc.
2,746,786	5/22/56	Coke oven door latch	Koppers Co., Inc.
2,746,787	5/22/56	Scrap charging bucket	Allegheny Ludlum Steel Corp.
2,746,913	5/22/56	Rich gas nozzle for regenerative coke oven with recirculation heating	Koppers Co., Inc.
2,746,914	5/22/56	Apparatus for changing the heating direction of regenerative coke ovens heated by preheated poor gas	Koppers Co., Inc.

There is a demand for copies of the following Yearly Proceedings:

1936 1937 1938

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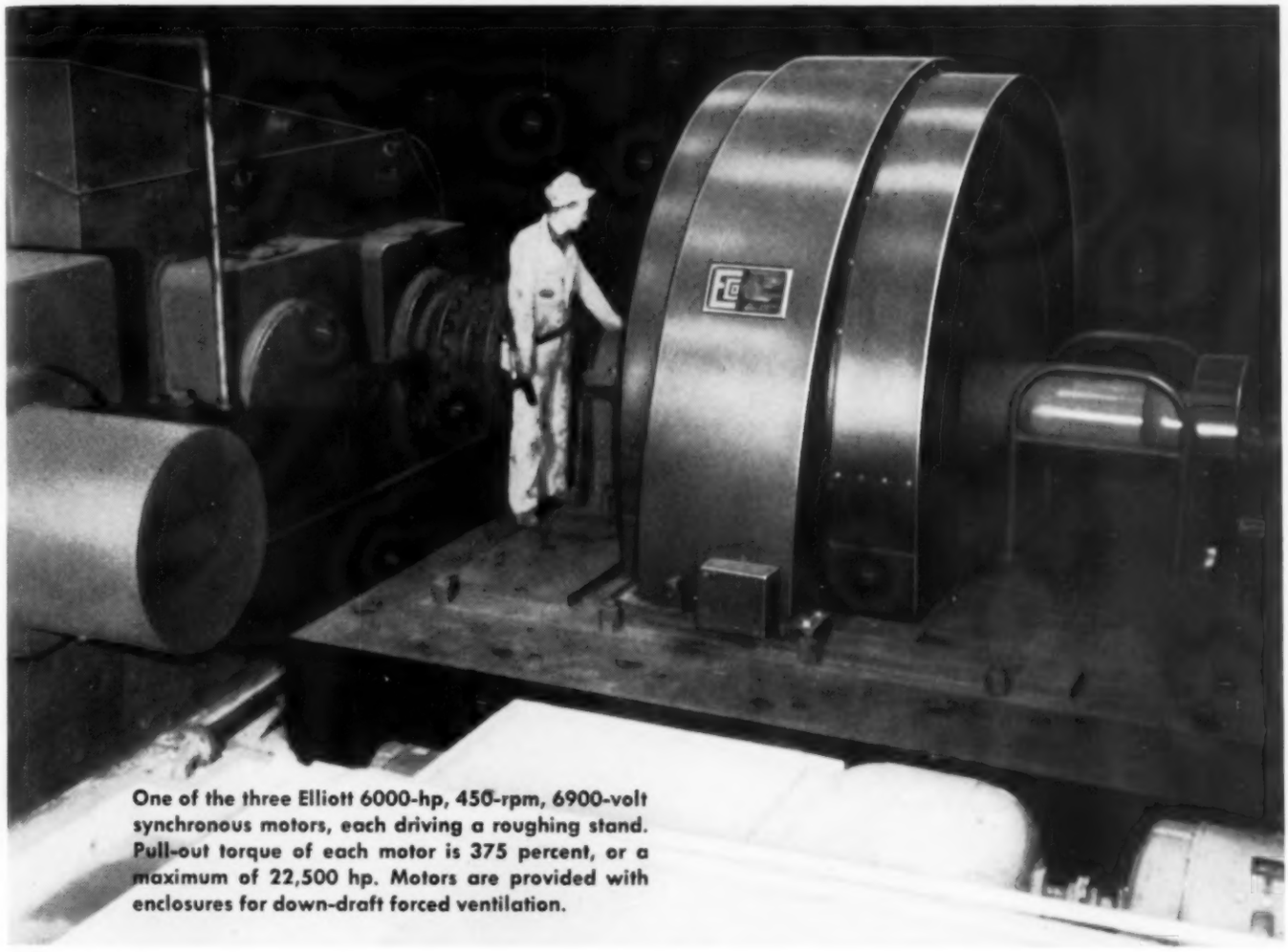
If your copies are not in use please get in touch with us.

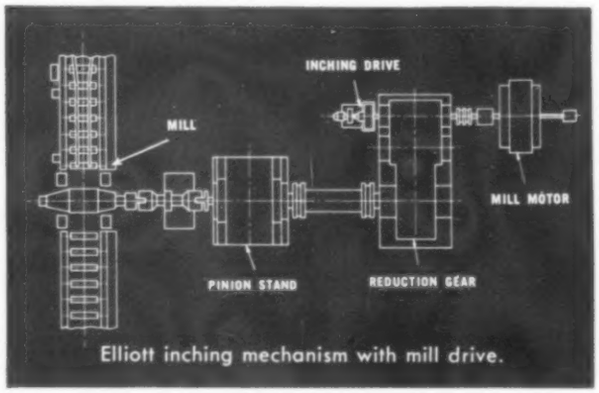
ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.



One of the three Elliott 6000-hp, 450-rpm, 6900-volt synchronous motors, each driving a roughing stand. Pull-out torque of each motor is 375 percent, or a maximum of 22,500 hp. Motors are provided with enclosures for down-draft forced ventilation.

World's fastest continuous hot strip mill features new Elliott mechanical inching drives.

The Weirton Steel Company, Division of National Steel Corporation, has an outstanding engineering innovation in its new 54-inch, 40-foot-per-second continuous hot strip mill in the application of the Elliott inching mechanism to each of the five roughing stands. Now, when replacing rolls, there is no need to jog the main mill-drive motor with line voltage and thereby risk circuit breaker damage. Nor is a complex or expensive electrical system needed. This simple inexpensive method consists of a gear-motor, geared to the drive as shown in the diagram, through an overrunning clutch. This system, without any electrical interlocking, can also assist in starting, thereby reducing starting peaks. Any desired combination of inching speeds and torques can be provided. It's the simple, inexpensive answer to inching requirements. For complete information, write Elliott Company, Ridgway Division, Ridgway, Pa.



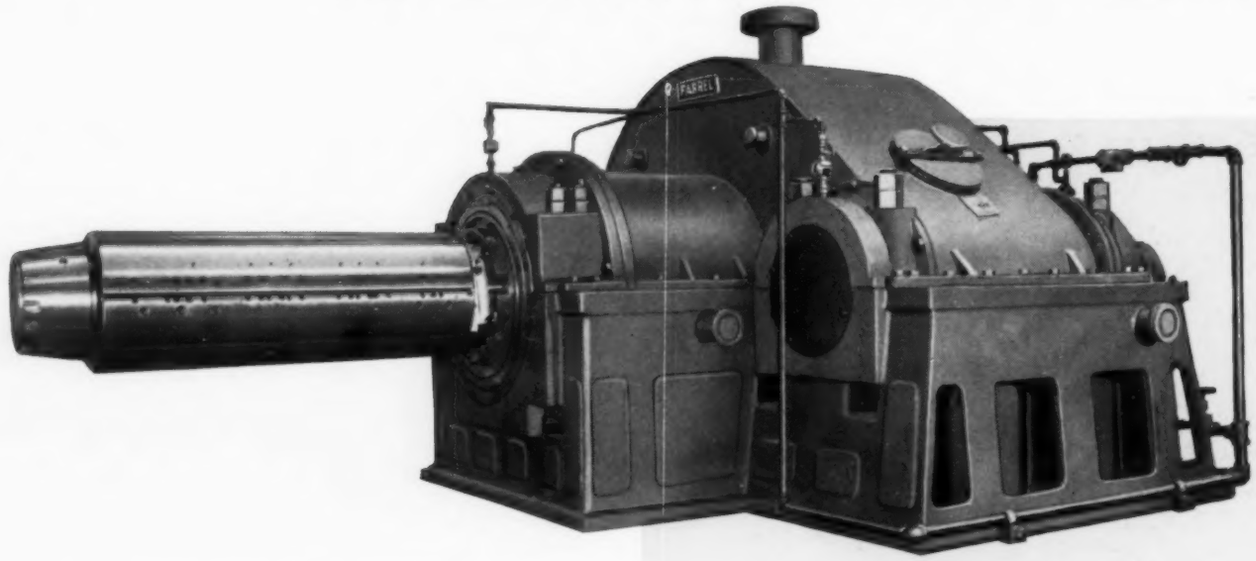
Elliott inching mechanism with mill drive.

ELLIOTT Company

R6-5

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

Here's an example of a tailor-made drive



Whatever your drive requirements for rolling mills or auxiliary equipment, no matter how unusual the design, size or capacity, Farrel will build you a unit to best handle the job.

As in the example given, each drive is tailor-made for the application. Power and speed, type and gauge of metal to be rolled, process (hot or cold), nature of load (continuous or intermittent), type of drive motor—all are taken into account in determining the size, material and type of construction.

This development of a Farrel drive assures optimum efficiency, plus the inherent strength to withstand the shocks, stresses and wear encountered in continuous, heavy-duty service.

Why not discuss your gear drive objectives with Farrel engineers?

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Akron, Chicago, Fayetteville (N.C.), Los Angeles, Houston

Farrel-Birmingham®

1500 HP WINDER DRIVE—This unit transmits power from an adjustable-speed motor, operating at 225/562 RPM, to a collapsible winder. Maximum block speed is 141 RPM; maximum strip speed is 738 feet per minute. Winder will handle a coil of 20" inside diameter, 48" outside diameter by 49" width. Maximum weight of coil 20,580 lbs. An exceptionally large main bearing carries the high overhung load.

WRITE FOR BULLETIN 275, which illustrates a few of the many types of rolling mill drives and pinion stands built by Farrel-Birmingham.

FARREL® METALWORKING EQUIPMENT: Rolls • Rolling Mills • Slab, Rod and Strip Handling Equipment • Roller Tables • Rod Coilers • Slitters • Gears • Gear Drives of Any Capacity • Mill Pinions • Pinion Stands • Universal Mill Spindles • Flexible Couplings • Roll Grinding Machines • Roll Calipers • Hydraulic Presses for Extruding, Forming, Drawing, Forging, Trimming, Hobbing, Straightening and Bending.

FB-1091

Specify... **J-M Asbestos Wick** **J-M Asbestos Rope**

Wherever you need general utility packings that are easy to handle, highly heat resistant

Throughout the iron and steel industries, the list of uses for Johns-Manville Asbestos Wick and Rope is constantly growing. These soft, resilient, heat-resisting materials are widely employed for general packing, gasketing and caulking applications.

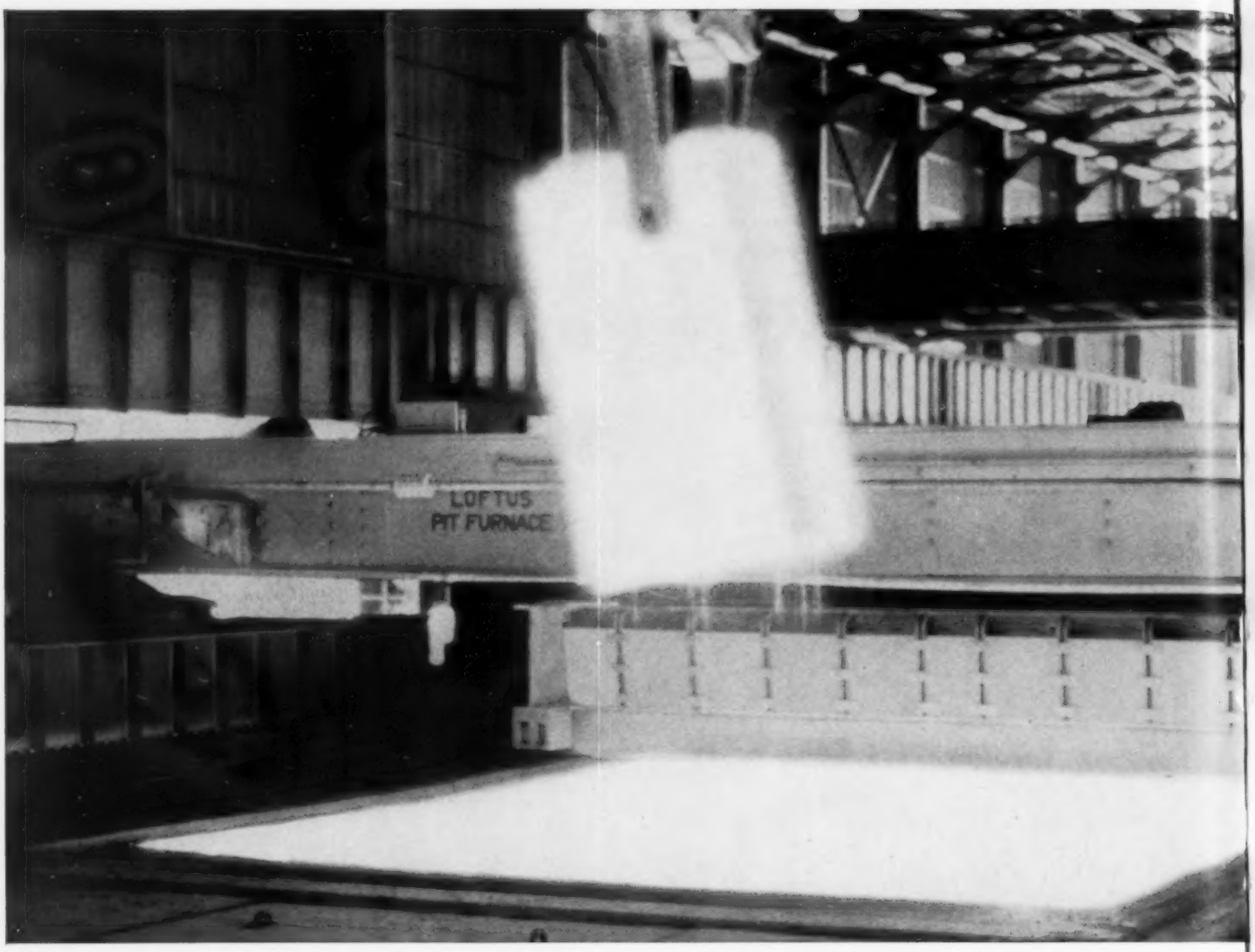
In coke ovens, both are used to caulk around the doors to prevent the escape of gases. Asbestos Rope (Style 4200) also serves as expansion joint material in the brickwork.

Only a few of the many applications for Asbestos Wick (Style 4202) can be given here. It seals hot metal in the ingot mould, around the top and between the mould and the stool. It gives protection from burning to water hoses that cool Open Hearth doors. It serves as a seal between the cope and drag on moulding flasks. It is used to wipe excess coating from wires after passing through the galvanizing bath.

Styles 4200 and 4202 are made from pure asbestos fibre carefully controlled for quality at Johns-Manville's own mine and mill (largest in the world). Asbestos Rope is formed by twisting together two or more strands of Wick to obtain the desired thickness. For further information, call your local J-M distributor or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Johns-Manville PACKINGS, GASKETS and TEXTILES

JOHNS-MANVILLE JM PRODUCTS



HAGAN CONTROL &

Provide Accurate Fuel-Air Ratio Control at U. S. Steel's CLAIRTON SOAKING PITS

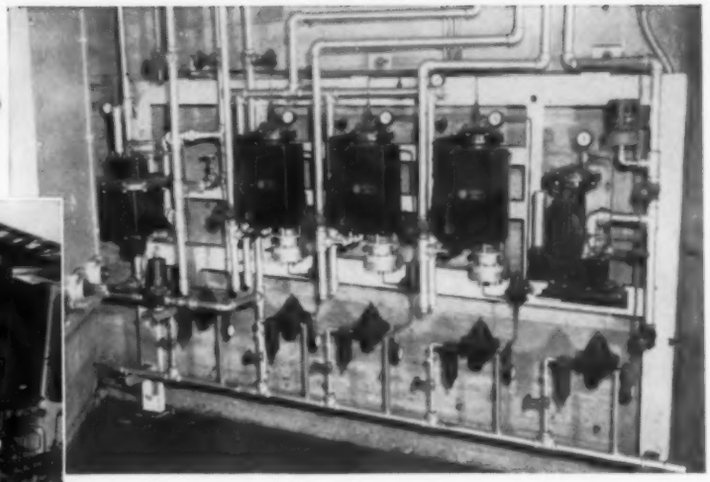
The newly rebuilt U. S. Steel Clairton soaking pits, designed by Loftus Engineering Corporation, are noteworthy for the comparatively short track time involved, the use of non-luminous flame (requiring higher air pressure), and the fact that they are used for treating a wide variety of steels.

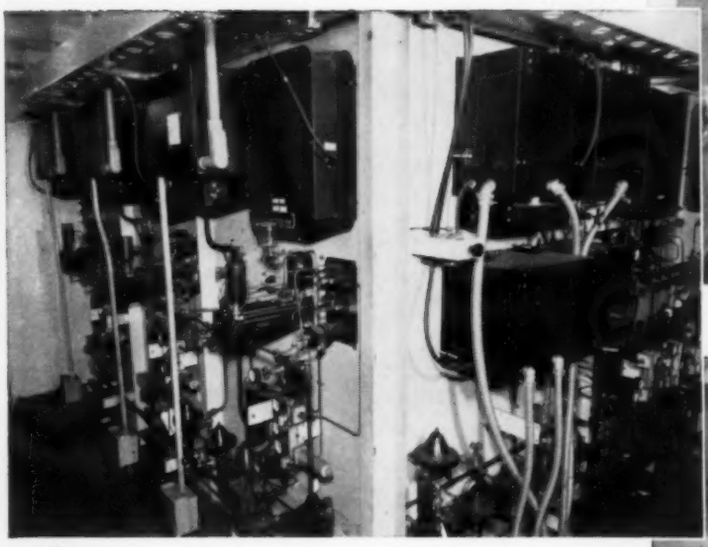
All of these factors demand accuracy and dependability in the control system. The Hagan systems now in use at Clairton provide more than the required precision, reliability and speed. Since the control lines are pneumatic, good housekeeping is easy, and safety is insured.

In addition to fuel-air ratio, the Clairton pits have Hagan control and metering of gas pressure, fan pressure, recuperator temperature and flue pressure. Hagan pneumatic systems are simple, direct-acting and are built to endure the most severe operating conditions.

Hagan's wide experience with automatic controls for soaking pits, blast furnaces, open hearths and heating furnaces is at your disposal. Call your nearest Hagan representative when you have a problem.

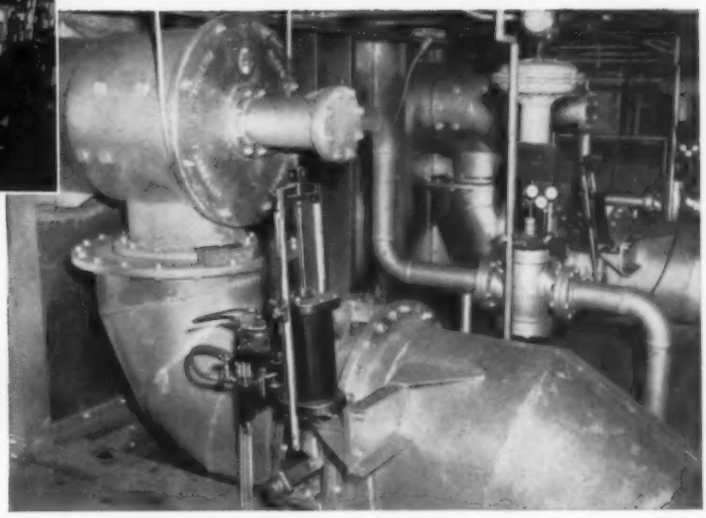
FLUE DRAFT, AIR FLOW AND COMBUSTION AIR TRANSMITTERS
Note simplicity of installation.





REAR OF CONTROL PANEL
Note accessibility.

PIT AIR DAMPER POWER UNIT
Precision positioning regulator—repeatability 0.5%.



INSTRUMENTATION

FUEL-AIR RATIO CONTROL regulates combustion air flow in proportion to gas flow to each pit. Automatic compensation is made for temperature variations of heated air. Gas and air flows are recorded, and gas flows integrated on Hagan Ring Balance Meters. Air-to-gas ratio is manually adjustable at the control panel.

PRESSURE CONTROLS consist of independent systems for the control of:

- Main line gas pressure for both rows of pits.
- Forced draft outlet pressure to each row.
- Pit pressure by positioning of stack dampers.

Interlocks cut off air and gas flow, and move stack damper to a pre-determined safe position when pit cover is lifted.

RECUPERATOR is protected against overheating at low flows by temperature control. Excess heated air is automatically bled off to atmosphere.

These Hagan Automatic Control Systems maintain operating conditions in the pits at high efficiency, so that production can be held to maximum levels with minimum scaling of ingots. Safety and cleanliness are assured with Hagan *pneumatic* controls.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

HAGAN BUILDING • PITTSBURGH 30, PENNSYLVANIA

Metallurgical Furnace Control Systems • Boiler Combustion Control Systems • Ring Balance Flow and Pressure Instruments • Control Systems for Aeronautical and Automotive Testing Facilities

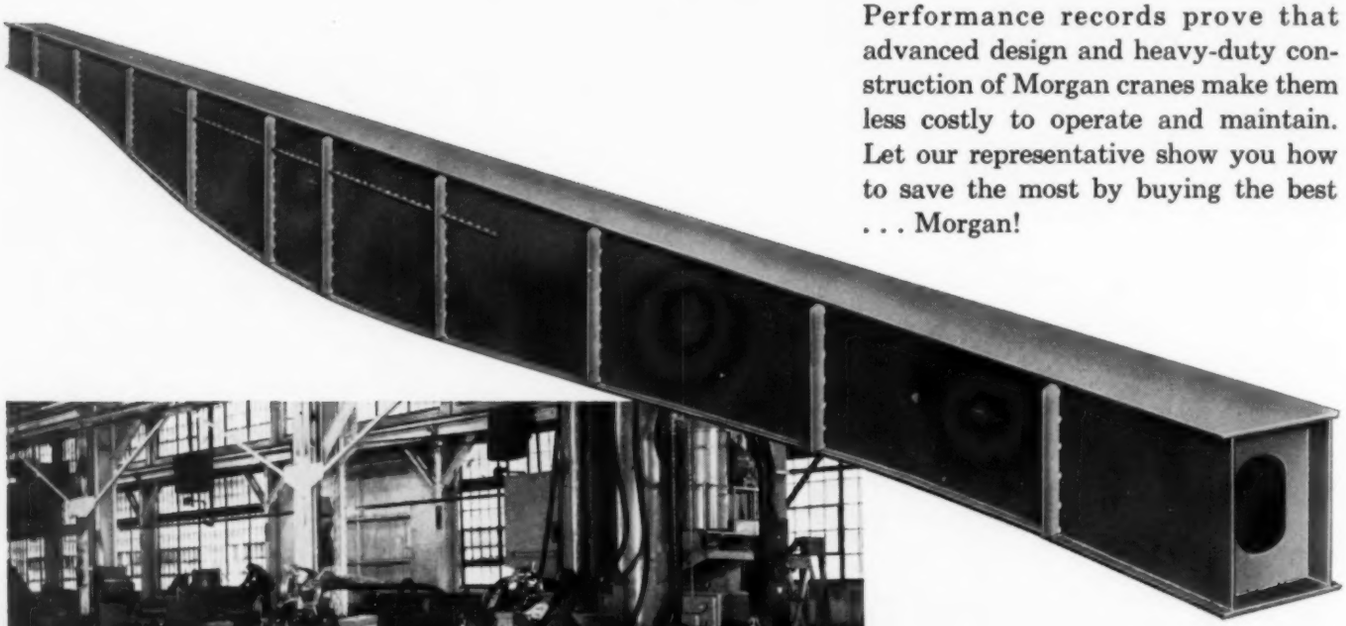
How Morgan cranes get a stiffer backbone ...automatically

● MORGAN CRANES are stronger, more rigid . . . because girder joints and seams are welded automatically on the world's largest continuous welder. Casting imperfections and hand welding variables are eliminated with Morgan automatic welding. All joints are uniform and sound.

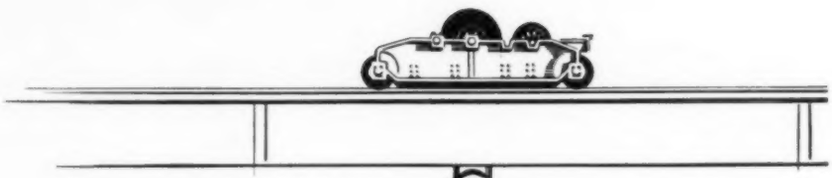
Crane drums, too, are welded automatically, making them stronger and lighter. Casting shrinkage voids are eliminated.

Morgan welders are qualified in accordance with A.S.M.E. and A.W.S. codes.

Performance records prove that advanced design and heavy-duty construction of Morgan cranes make them less costly to operate and maintain. Let our representative show you how to save the most by buying the best . . . Morgan!



Perfect welding penetration is obtained with Morgan's 120" per minute automatic welder. Two welding heads float vertically and horizontally along the track.



The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, charging machines, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.

THE MORGAN ENGINEERING CO. *Alliance, Ohio*

you live with BRICK . . . 24 hours a day!

365 days and nights a year—wherever you go and whatever you do—you come in contact with products born in and from refractory brick.

Your car and everything in it . . . the cement you drive on . . . the gasoline that powers you—*everything* you see or touch . . . everything that's made or moves owes its very existence to refractory brick. Refractories—containing and controlling the many flames of industry—produce the steel, electric power, rubber and cement you use *continuously* in daily living.

Therefore, the making of refractory products is the most basically necessary industry there is. Refractories, you see, create industry . . . without them, there would be no industry.

Providing industry with Castables, Plastics, Ramming Mixes, Fire Brick, Mortars, Insulating Brick and Insulation, General Refractories Company draws resources from all over the globe—and operates the world's largest, most-modern refractories research laboratory.

A Complete Refractories Service
GENERAL REFRACTORIES COMPANY
Philadelphia 2, Pa.

A COMPLETE REFRACTORIES SERVICE FOR THE STEEL INDUSTRY

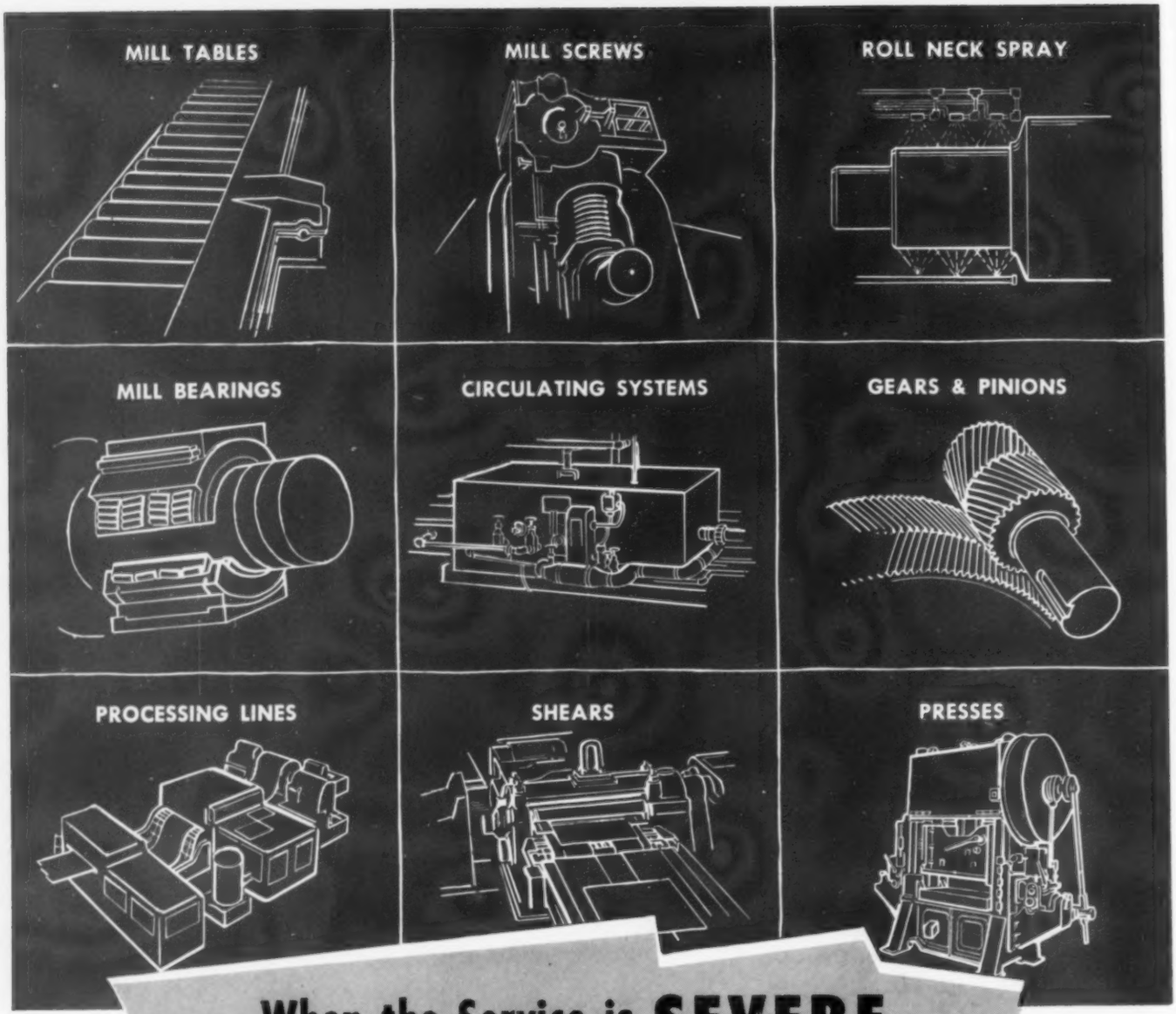
OLIVE HILL BF and OLIVE HILL HI-FIRED brick rank high in any list of prominent and widely used brands of blast furnace refractories. Manufactured from dense-burning Kentucky flint fire clays by Grefco's unique manufacturing processes, OLIVE HILL brick set a standard for blast furnace refractory quality and workmanship.

Grefco processing of OLIVE HILL brick entails:

1. Careful selection, testing, stockpiling and blending of fire clays to insure uniform raw material quality.
2. Grinding and screening to prescribed formula to promote high density of product.
3. Efficient deairing during brick forming, also to promote density and proper physical structure.
4. Careful firing to exacting temperature schedules to yield uniform high quality brick.
5. Close inspection of final product with gauging and sorting of brick to close size tolerance.
6. Quality control by statistical analysis procedures for the manufacturing processes.

In service, OLIVE HILL blast furnace brick, both BF and HI-FIRED, have produced many splendid performance records in the past. OLIVE HILL linings in presently operating furnaces, are giving outstanding performance and are more than meeting the increasing requirements of the expanding American Iron and Steel Industry.

GENERAL REFRACTORIES



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—you're better off with Brooks LUBRICANTS

The unique properties of Brooks lubricants have provided outstanding service where other quality lubricants have proved inadequate. Brooks lubricants are remarkably resistant to water or moisture conditions and abrasion. Brooks lubricants are non-corrosive, adhesive, and extremely stable in long periods of production service; maintaining a *minimum* pH-ilm strength of 25,000 psi. Extended equipment service and reduced lubricant consumption can be assured in practically all severe applications.

Write for Engineering Data Bulletin on your particular application.

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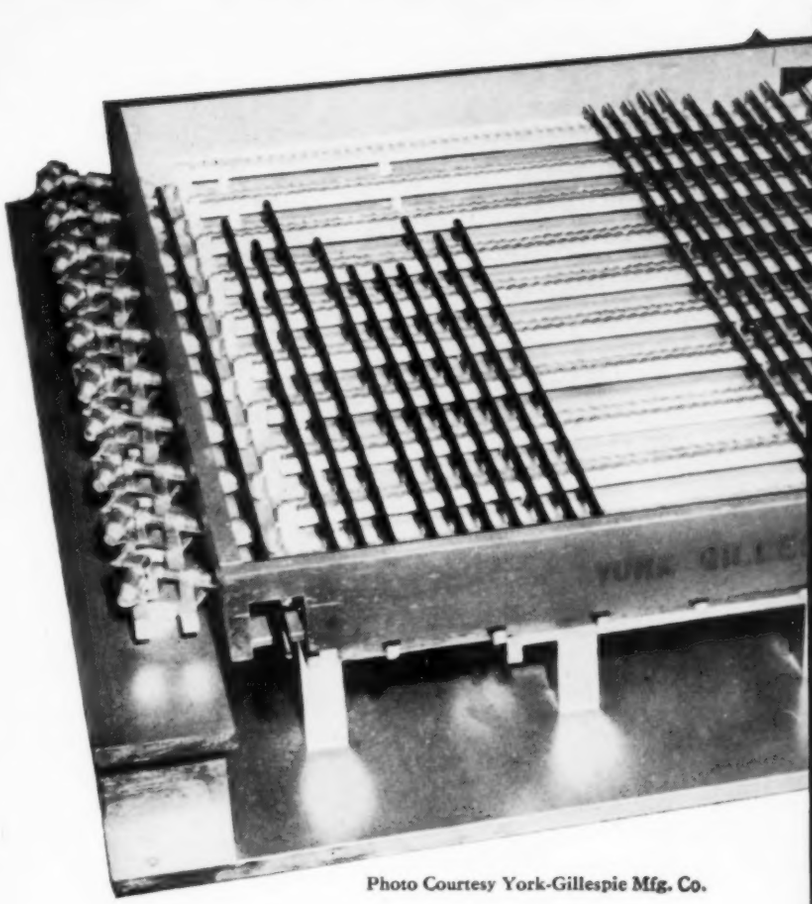

Photo Courtesy York-Gillespie Mfg. Co.

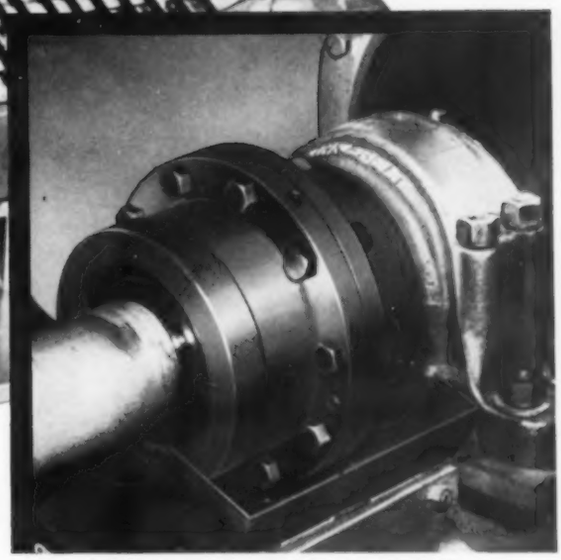

Photo Courtesy Jones & Laughlin Steel Corp.

Fast's Couplings help roll 30 tons of steel per hour through new Jones & Laughlin normalizing and quench tempering furnaces

At the Jones & Laughlin Aliquippa Works, Fast's Couplings are part of a new materials-handling process for transferring tubular steel products through the continuous normalizing and quench tempering furnaces. Pipe tubing is rotated automatically by a series of specially designed racks as it is transferred through the furnace. This design eliminates chill spots and minimizes warpage, insuring uniform heating at capacities up to 60,000 pounds per hour.

Fast's Couplings were used exclusively in this equipment . . . and for good reasons: They are subject to operation at extremely high temperatures that demand Fast's all-steel construction; torque transmission is high (low 3 RPM speed at eccentrics); Fast's Couplings offer mis-alignment protection for long-distance shafting—particularly important because of high temperatures and subsequent shaft growth; and Fast's Couplings are the best "shut down insurance" where continuous, trouble-free operation is essential.

This is another example of how Fast's Couplings fill specialized needs of industry with their famous Fast's construction and performance features. Koppers free engineering can assist you in selecting the right Fast's Coupling for your needs also. Mail the coupon below for a free catalog to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 3010 Scott St., Baltimore 3, Maryland.

THE ORIGINAL **FAST'S Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus. *Engineered* **Products Sold with** *Service*

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* **3010 Scott St., Baltimore 3, Md.**
Gentlemen: Send me a Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

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Company.....

Address.....

City.....Zone.....State.....

To help you cut production costs . . .

NEW General Electric

D-c Power Source

KINAMATIC* — — — a new standard in direct-current generators and motor-generator sets—designed to give you higher output at less cost.

As a progressive manufacturer, you are faced with the problem of boosting factory output and beating rising production costs. Where your production process involves adjustable speed, tough duty cycles, frequent reversals or speed matching, you may have already applied the performance advantages of d-c drives. To help you further boost production and reduce your automation costs, completely new sources of constant and adjustable-voltage d-c power are now available—General Electric d-c Kinamatic generators and m-g sets, ¾–100 KW.

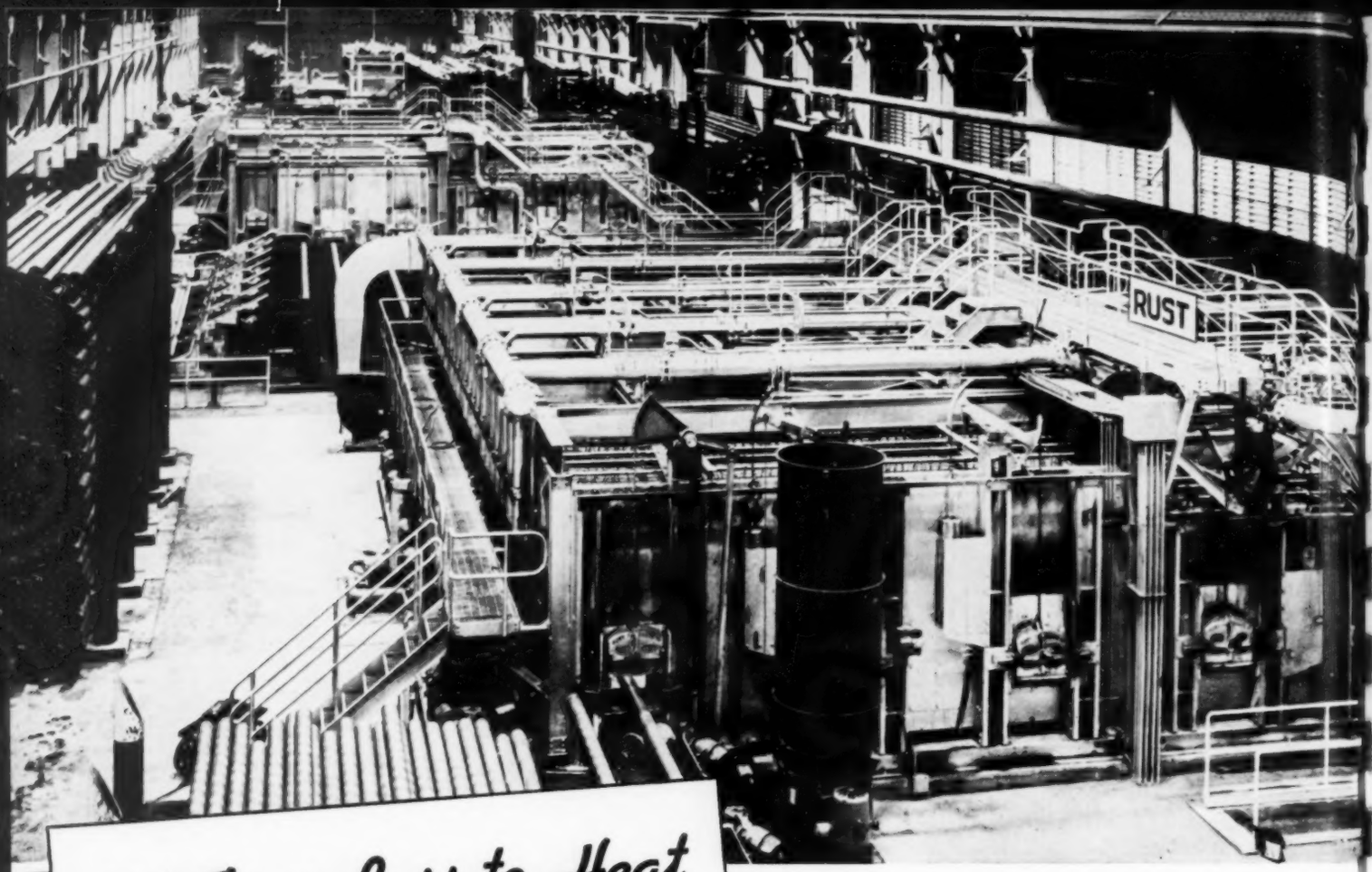
More Power Per Dollar—D-c Kinamatic generators pack more power per frame size than any previously designed G-E generator. Nine new kilowatt ratings more closely match both the power requirements of your standard d-c drive motors and the power output of standard prime-moving a-c motors. This new matching gives you a more efficient, more compact adjustable-voltage drive at lower cost.

And a Lot More—A d-c Kinamatic generator or motor-generator set can give you much more than savings on initial automation costs. If you would like to know more about the construction details, advanced performance characteristics and money-saving maintenance features of d-c Kinamatic generators and m-g sets, we would like to have a G-E Apparatus Sales Representative call on you. Or, if you prefer, we will send you copies of GEA-6461 and GEA-6355. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 813-2

* Trade mark of General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC



116 Tons Less to Heat in this roof

because of B&W Insulating Firebrick suspended construction

Here's another case where light weight means lower cost. The roof of this walking beam furnace is 2,320 square feet. B&W Insulating Firebrick suspended construction for a 9-inch roof weighs about 30 lbs per square foot, including the weight of rods, hangers, pipe, brick and mortar. This is approximately 100 lbs per square foot less than an arch constructed of heavy firebrick plus insulation having the same heat flow. *This saving means the B&W IFB roof is 116 tons lighter.*

The new walking beam furnace (shown in photograph above) was designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation. Seamless pipe is conveyed into the furnace, moves slowly from left to right on walking beam rails designed and furnished by York-Gillespie Mfg. Co., and passes out the exit door.

Here are the money-saving benefits of B&W suspended construction:

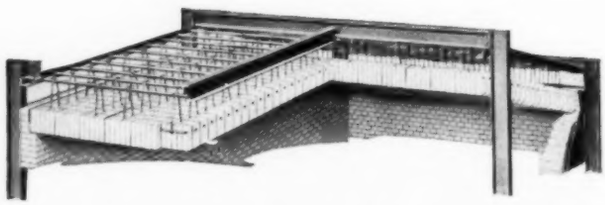
1. Supporting steel is less massive, far less costly. Commercial size steel can be used for roof suspension instead of special castings.

2. B&W Insulating Firebrick heat up and cool down faster. This means lower fuel costs, faster inspection.

3. Furnace temperatures can be changed quickly. When different steels call for different heating schedules, the furnace temperature can be adjusted in minutes instead of hours.

4. Installation costs are lower because these lightweight brick can be handled faster and easier than ordinary heavy firebrick.

For complete information on B&W IFB—the *lightest* weight insulating firebrick, write to B&W today or call your local Refractories Engineer.



This is a cross-sectional drawing of a typical suspended arch arrangement using B&W Insulating Firebrick. It can be used in flat or sloping roofs, nose arches and many other types of suspended furnace construction.

BABCOCK & WILCOX

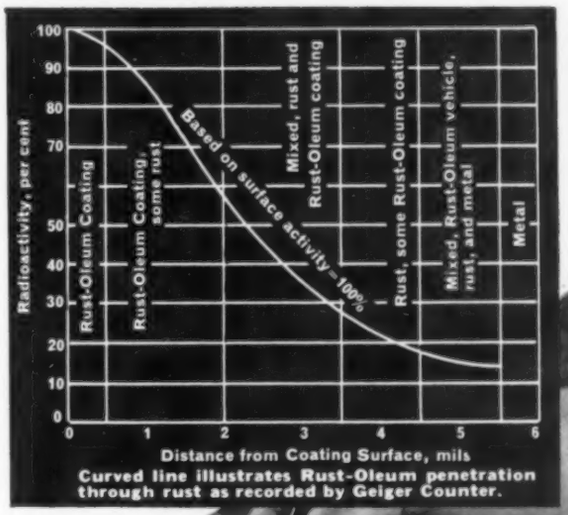
THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

RUST-OLEUM®

PENETRATION

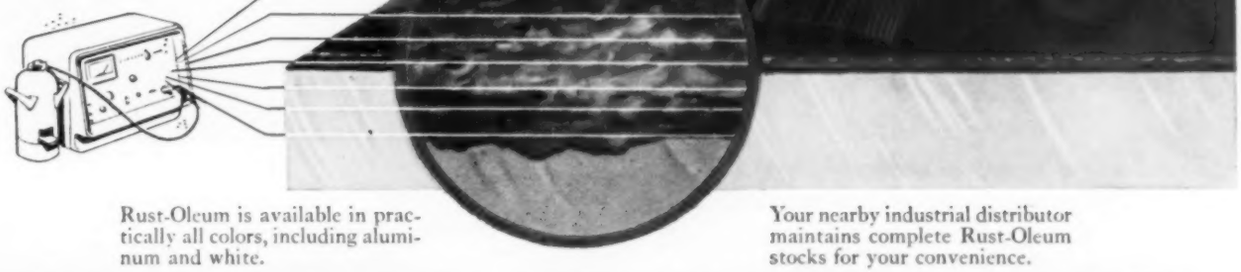
through rust to bare metal traced by Geiger Counter. To effectively stop rust—the vehicle of a protective coating, when applied over a sound, rusted surface—must penetrate through the rust down to bare metal. **Rust-Oleum does exactly that!—as proved by radioactive research!** Rust-Oleum's specially-processed fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer—then applied to rusted test panels. Penetration *through rust* to bare metal by Rust-Oleum's specially-processed fish oil vehicle was then traced by Geiger Counter.

You stop rust, because Rust-Oleum's fish oil vehicle soaks deep down to bare metal and into the tiny pits where it drives out air and moisture that cause rust. You save, because this same *penetration* enables you to apply Rust-Oleum directly over rusted surfaces—usually eliminating costly surface preparations. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists.



Curved line illustrates Rust-Oleum penetration through rust as recorded by Geiger Counter.

There is only one Rust-Oleum. It is distinctive as your own fingerprint. Accept no substitute. Buy—and specify only Rust-Oleum. You'll be happy that you did.



Rust-Oleum is available in practically all colors, including aluminum and white.

Your nearby industrial distributor maintains complete Rust-Oleum stocks for your convenience.

RUST-OLEUM®

STOPS RUST!

See our Catalog in Sweets, or write for complete information.

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- ☐ Complete literature including color charts.
- ☐ Thirty-page report on Rust-Oleum penetration.
- ☐ Nearest source of supply.

BLAW-KNOX

makes what it takes

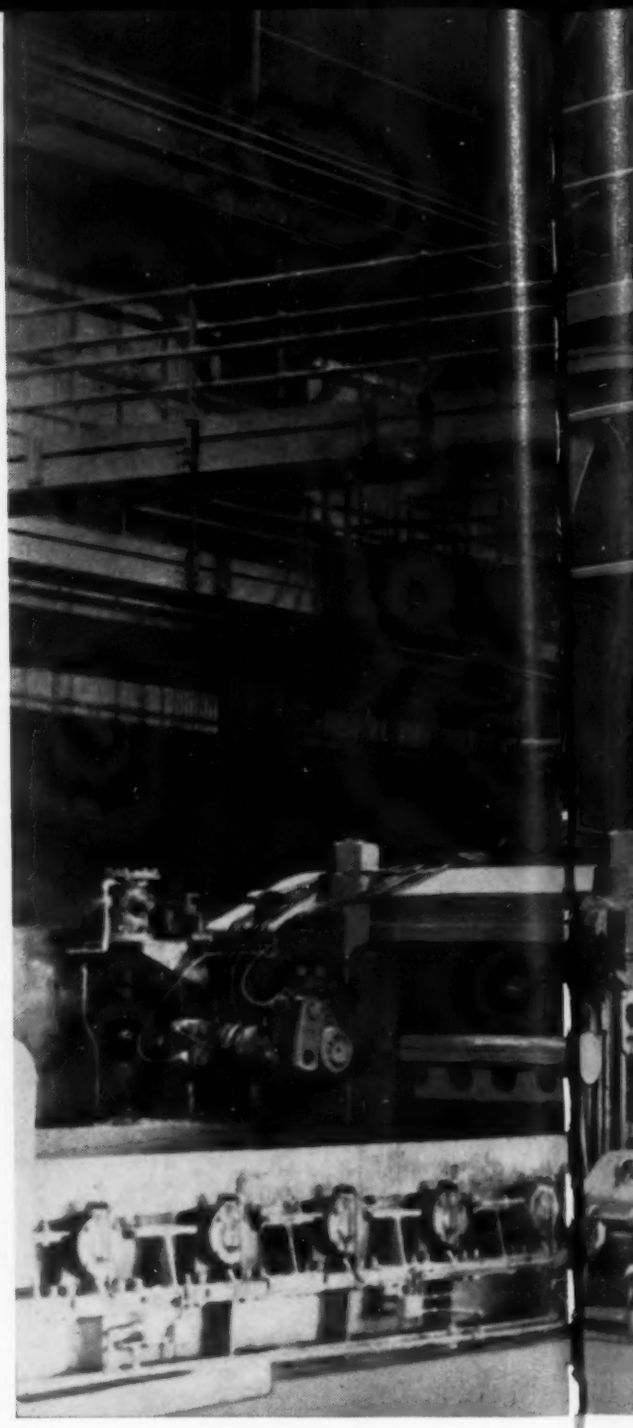
to hot roll high-tonnage

top quality sheet

This CONTINENTAL 80-inch, 6-stand continuous hot strip mill in the United States Steel's Gary Sheet and Tin Mill was designed and engineered for heavy duty and high-speed finishing. It is well-known throughout the industry for excellent tonnage performance and quality.

In addition to these large mills, Blaw-Knox builds single-stand reversing hot strip finishing mills, complete with all auxiliaries.

Blaw-Knox designs and builds *complete* rolling mill installations—assumes undivided responsibility from preliminary engineering to satisfactory operation. At any time we'll be glad to discuss your plans with you.



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Foundry & Mill Machinery Division
Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

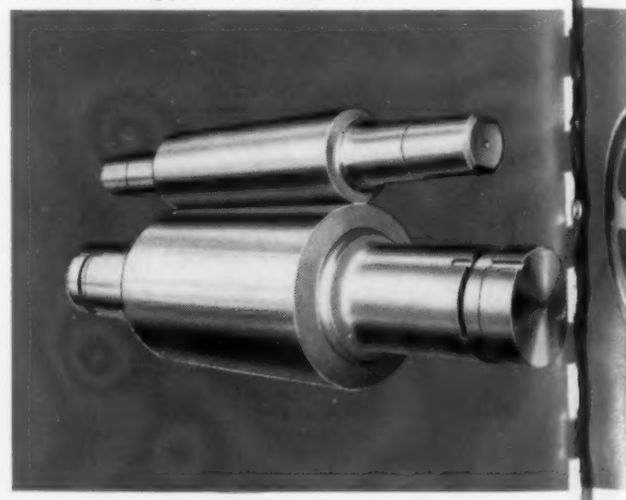
Complete rolling mill installations . . . including all auxiliary equipment . . . for ferrous and non-ferrous metals

Hot strip mills • cold strip mills • slabbing mills • temper mills • universal mills • plate mills • blooming mills • structural mills • rail mills • billet mills • rod mills • merchant mills . . . roll lathes • chippers • special machinery • and complete auxiliary equipment

50th Anniversary
BLAW-KNOX
1906-1956

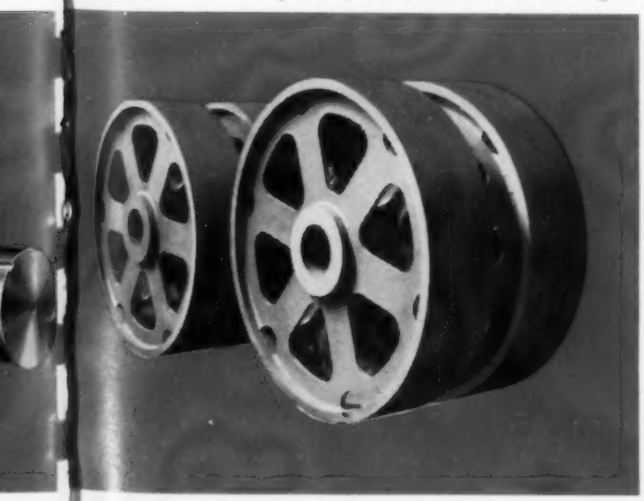
CONTINENTAL

ROLLS—Iron, alloy iron and steel rolls for all types of rolling mills.

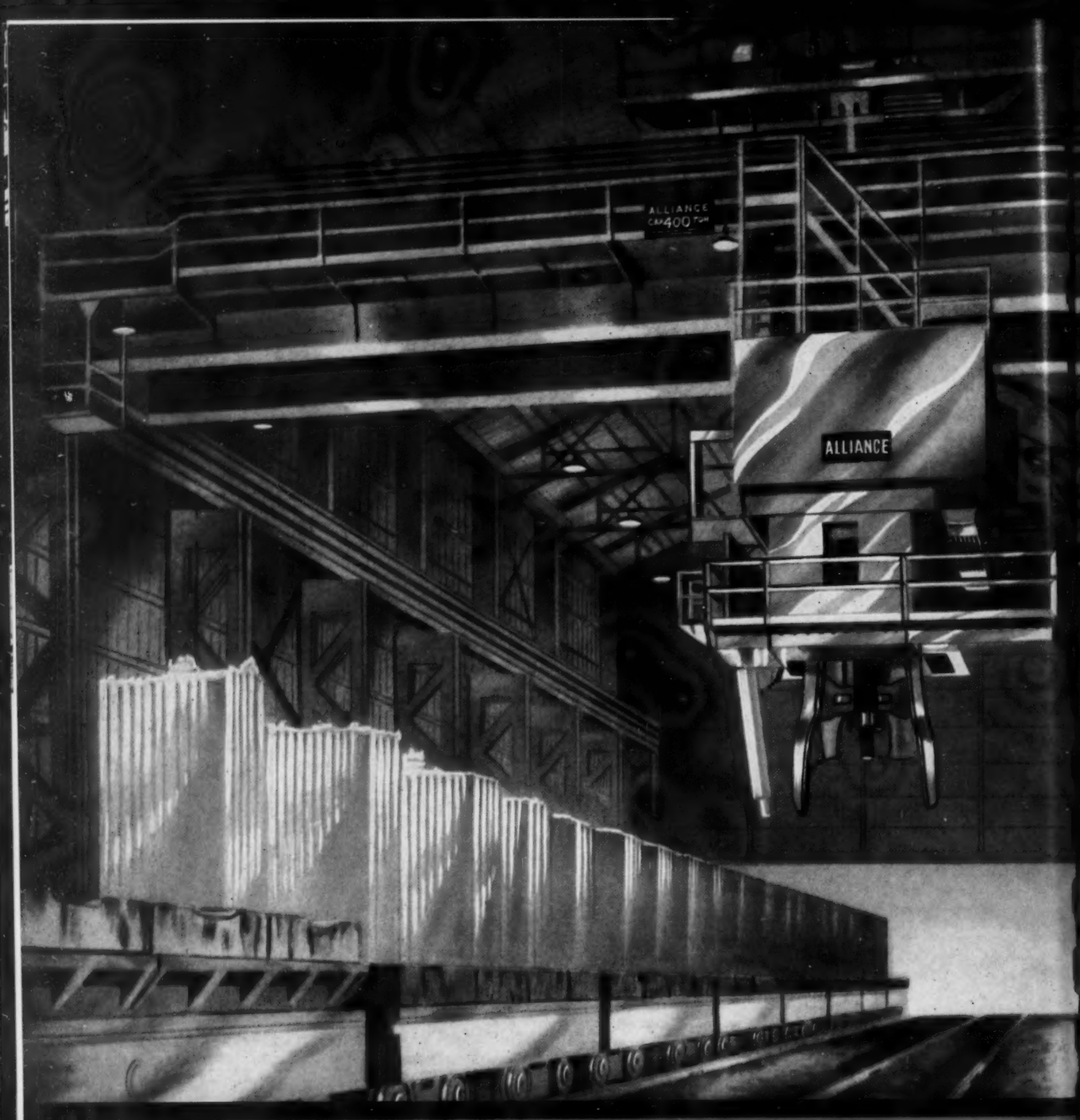


CONTINENTAL 80-inch continuous hot strip mill in the Gary Sheet and Tin Mill of the United States Steel Corporation.

WELDMENTS—fabricated steel plate, or cast-weld design.



CASTINGS—carbon and alloy steel castings from 20 to 250,000 pounds.



THE WORLD'S LARGEST STRIPPER CRANE

• This 400-ton Alliance push-pull Stripper Crane is the world's largest. It can exert 2,400,000 pounds' pressure to strip moulds from ingots — cleanly and safely. The patented Impact Stool Loosener speeds up the stripping operation. The stripping mechanization has a nominal rating of 400 tons but is designed to stand forces of 1200 tons. Its many exclusive design features are a result of Alliance's knowledge of mill problems and requirements. They design the world's biggest cranes, manipulators and special machinery. Their experience assures you the best in modern design. A letter, wire or phone call will put your problems into the hands of The World's Largest Builders of the World's Largest Cranes.

THE ALLIANCE MACHINE COMPANY

EXCLUSIVE with ALLIANCE

The Alliance Impact Stool Loosener makes your stripper crane more useful, more efficient and saves wear and tear on the crane and ingot buggies. The Impact Stool Loosener can be installed on most stripper cranes now in your service.

Alliance

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

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The Atlantic specialist in industrial lubrication is a highly skilled expert. He's spent years in the study of every heavy lubricating and cutting-oil problem . . . and he's backed by other Atlantic specialists in lubrication research, production, quality control and marketing.

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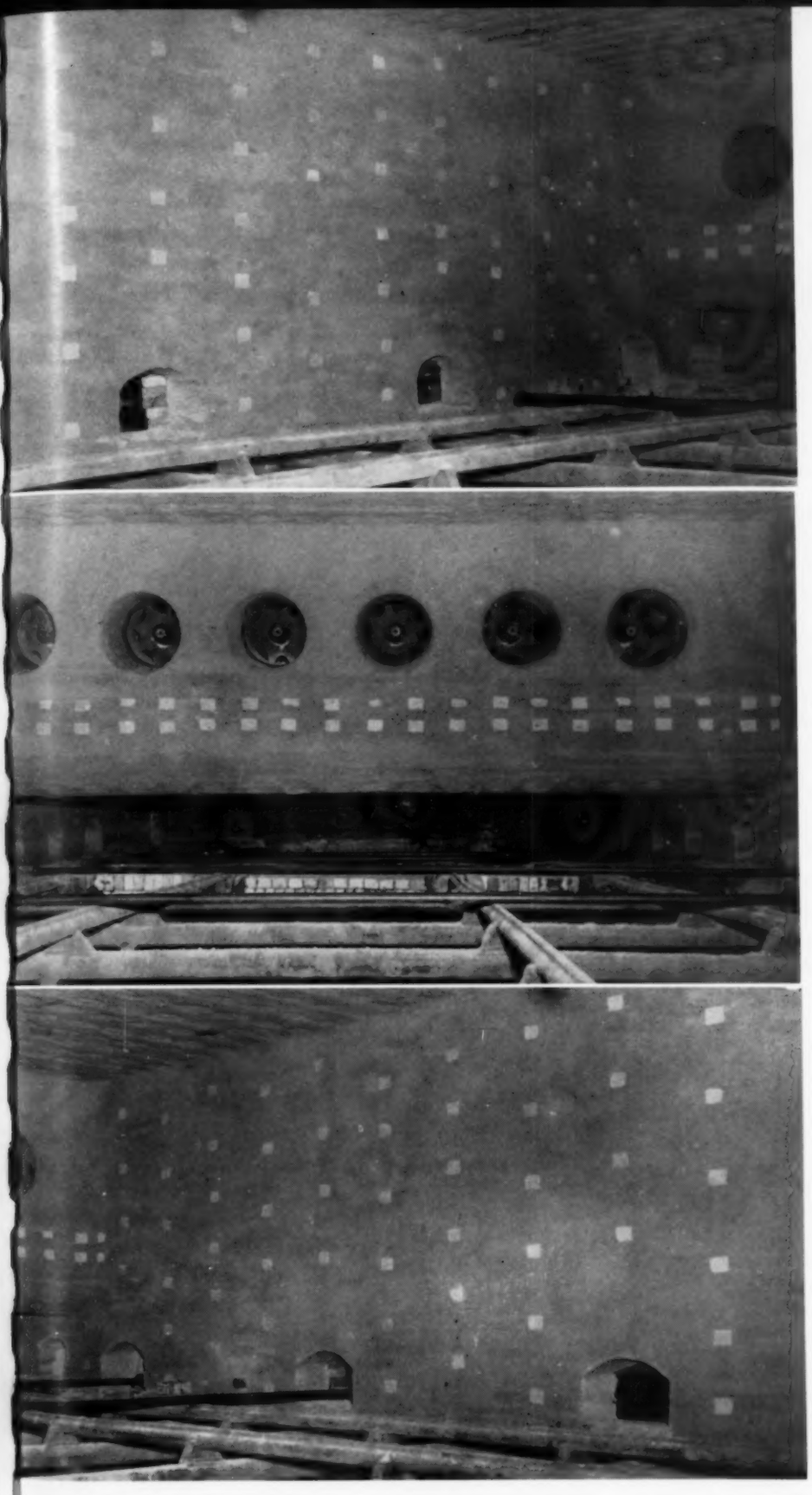

PAST PERFORMANCE PAVES THE WAY TO A

COMPLETE RAMTITE® ENCLOSURE

of a triple fired slab heating furnace at U. S. Steel, Irvin works, Dravosburg, Pa.

Five years previous experience with Ramtite in triple fired slab heating furnaces led to the installation of a complete Ramtite enclosure in the No. 4 furnace at this mill.

One radical change was made at the time of the Ramtite installation. The steel casing was eliminated and 3/8" of plastic insulating material was troweled on the outside of the Ramtite walls.

Ramtite's monolithic construction, no joints, provides an air-tight, flame-tight, gas-tight structure and assures continued trouble-free performance.

The Ramtite Co. offers you a complete sales engineering service — experienced men who are always available to study your refractory problems and consult with your Mason Superintendent about your specific needs.

For further information about Ramtite products and services, contact your local Ramtite representative or mail the attached coupon.

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Please send items checked

- ☐ Bulletin on Castable and Gunning Refractories
- ☐ Steel Plant Bulletin

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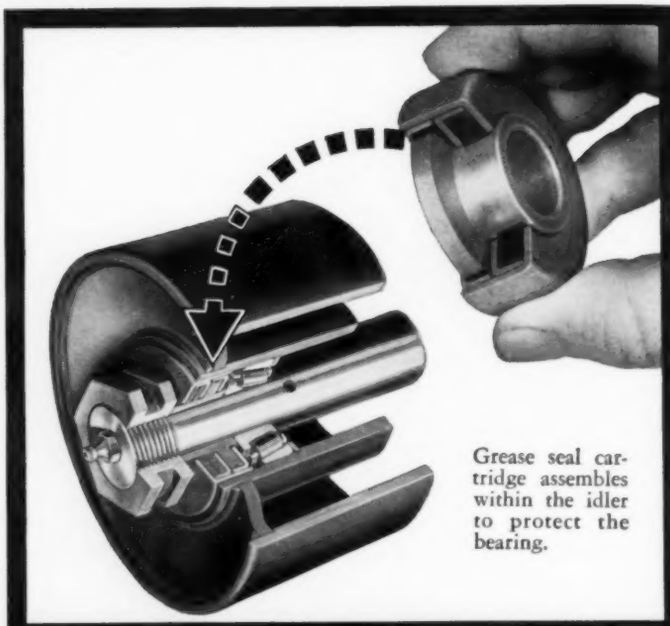
This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

Today's simplest IDLER GREASE SEAL is also the best-performing

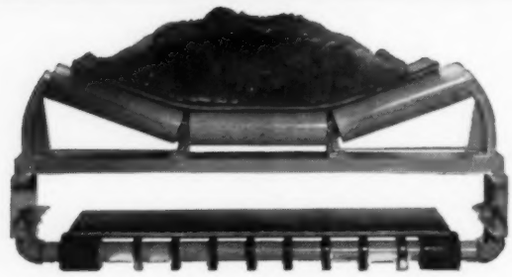
THE cartridge grease seal used on Link-Belt belt conveyor idlers provides the effectiveness of multiple sealing with the convenience of a single unit. A contact seal of laminated felt and neoprene combined with a labyrinth keeps dirt out, grease in. And the grease itself within the labyrinth further prevents entrance of dirt or other matter. What's more, no springs or loose washers are involved . . . there's no chance for metal-on-metal friction. The entire assembly comprises a rugged, compact "cartridge."

Simplicity is only one of the big advantages you get with Link-Belt idlers. Check the others below. For complete facts ask your nearby Link-Belt office or authorized stock-carrying distributor for a copy of Book 2416. It lists over 500 sizes in 34 types, including troughing, variable troughing, flat belt, belt training and rubber cushion idlers.

Sturdy, rigid frames support rolls in perfect alignment. Rolls are securely held in place but easily removed for inspection and service.



Grease seal cartridge assembles within the idler to protect the bearing.



You'll find these 6 features throughout industry's most comprehensive idler line

1. **HUSKY, HIGHEST QUALITY BEARINGS,** free and easy turning, assure maximum life, minimum belt-wear, low power consumption. Concentricity is secured by unit mounting of bearings in a heavy-wall center tube.
2. **SAFE, CONVENIENT GREASE FITTINGS** protected by flange ribs of support brackets provide ease of lubrication—lubrication for longer life.
3. **CONCENTRIC ROLLS** have smooth surfaces and rounded edges. Machine-made, continuous welds prevent entrance of dirt and moisture.
4. **HOP-FREE ROTATION** is assured by close tolerances, press fits and precision assembly from shaft to shell.
5. **STRONG, RIGID FRAMES** support rolls in perfect alignment. Rolls are securely held in place but can be easily removed for inspection and service.
6. **GROOVED HEX NUTS** lock into malleable brackets, creating bridge truss effect—prevent shaft rotation and bracket spreading under load.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,808

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

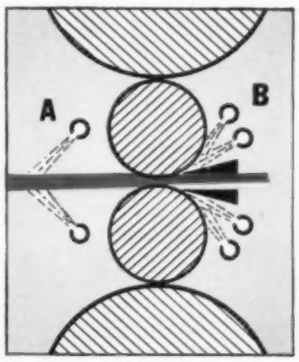
Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

Choosing work rolls for hot strip finishing trains

In continuous hot strip mill operation, the highest frequency of time-consuming roll changes usually occurs in the early stands of the finishing train. Conditions here are severe: the reductions taken are heavy, and the strip is still thick enough to carry much of its original heat.

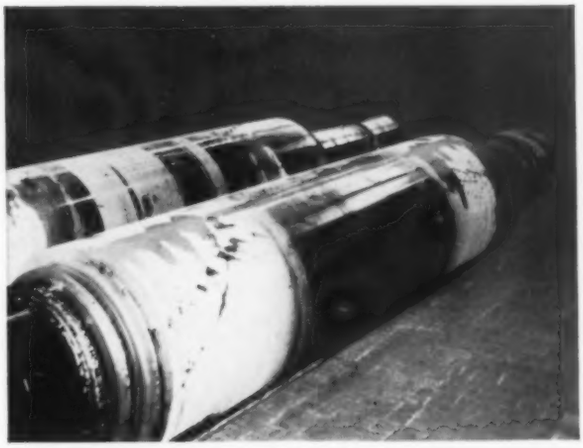
Water: the secret of longer roll life—Banding is a chief cause of premature roll failure in these stands. This peculiar tendency is related to the amount and size of graphite in a roll's surface, and to the adequacy of the cooling system. At high temperatures, graphite tends to pull out of the surface, leaving tiny fissures. Rolling pressure then forces in small particles of scale. These offer footholds for further scale build-ups, which are rapidly rolled into elongated bands.

Thus, cooling is vital. Water should be applied at a pressure of 140-to-200 psi, and in such a way that a large volume actually reaches the roll surface. The nozzle arrangement should be designed to create uniform cooling over the entire work surface. In some cases, additional sprays on the pass line are necessary.



EFFECTIVE WATER APPLICATION includes high-pressure sprays (A) aimed against the strip to push the scale out of the rolls and high-pressure water (B) in large quantities applied to the roll surfaces as close to the point of contact with the strip as the mill design permits.

Choice of rolls can make or break a rolling schedule—Where it is impractical to cool the rolls thoroughly, it is still quite possible to minimize roll changing by using Mack-Hemp *Midland Superalloy* rolls. These are nickel-chromium-molybdenum alloy steel rolls containing no graphite and capable of being heat treated to high hardness levels. As a result, they are extremely resistant to spalling and fire cracking, affording no foothold for scale.



ROLL BANDING on hot strip mill work rolls is a principal cause of uneven gage across the width of the strip. It brought about the early removal of this pair of rolls.

Where rolls can be adequately cooled, *Mack-Hemp Nironite "F"* double-poured high-nickel grain rolls actually will roll greater tonnages than alloy steel rolls. The indefinite chill of the first pour keeps the graphitic content of the iron low near the roll surface, while the second pour produces a strong, ductile core.

For less severe conditions, the *Mack-Hemp Nironite A or B* grades of grain roll give an excellent account of themselves. Although they show more graphite near the surface, they frequently turn in surprising tonnages between roll changes.

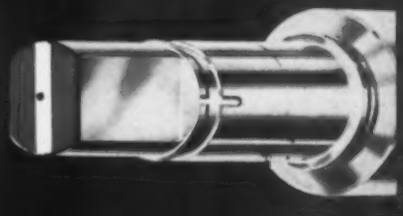
Mack-Hemp is as interested as you are in securing maximum output from your mills. If there are troublesome "roll-wreckers" among them, why not call upon us for help in selecting rolls to beat your special problems? There's no obligation. Write us today.

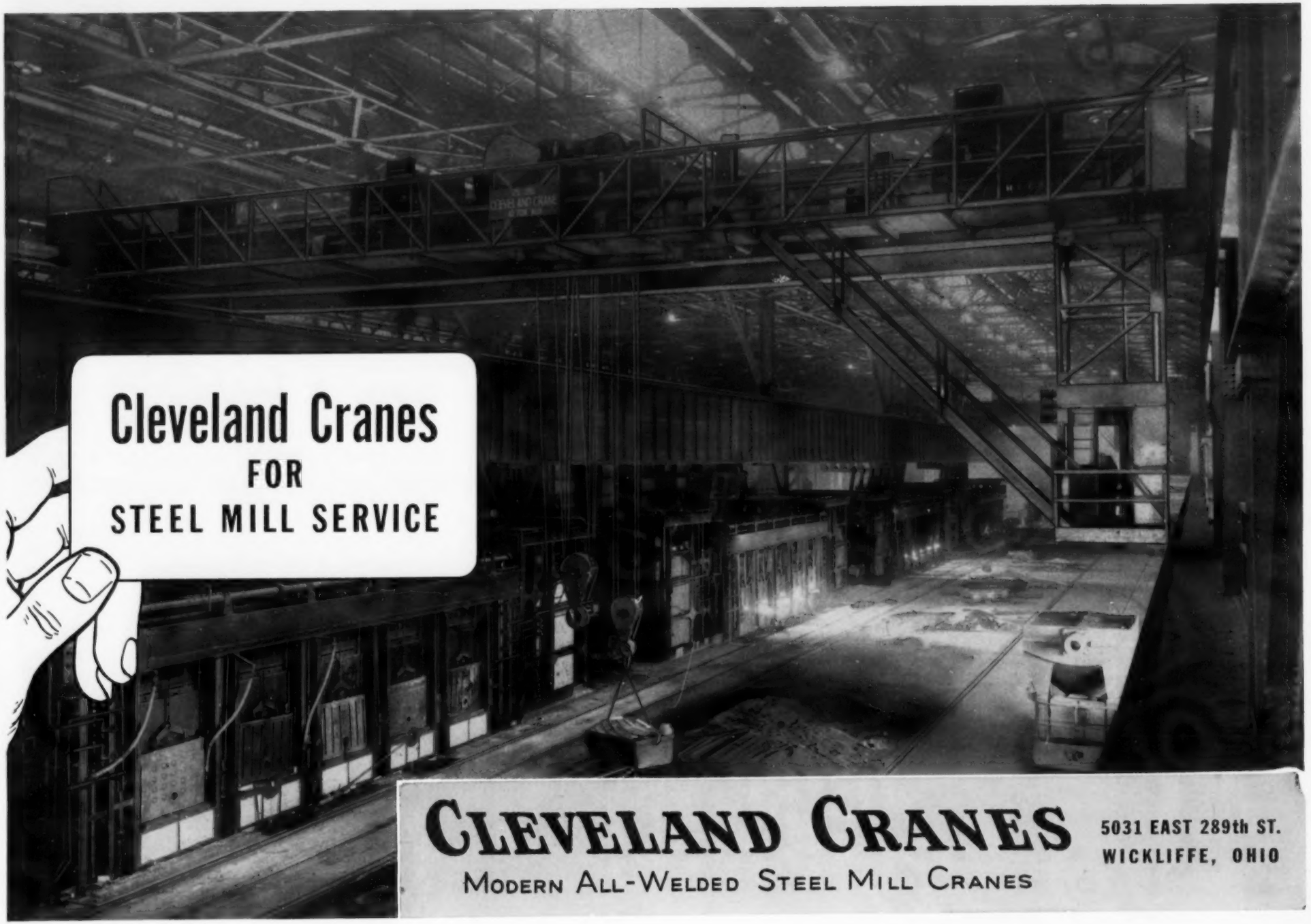
MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery

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MODERN ALL-WELDED STEEL MILL CRANES
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Crops *and* Shorts

ANOTHER AISE Convention and Iron and Steel Exposition has become history, but this 1956 affair set some records — more exhibit space than ever before and largest banquet on record (over 1300). Attendance totaled 13,606, second highest in numbers (14,668 in 1952) but highest in quality, according to exhibitors' comments. Exhibits seemed more interesting and visitors consequently spent more time at the show.

Trying to convince T. E. Cyphert, a design supervisor for McDowell Co., that he had won the Ford Thunderbird at the Exposition made us realize how hard it is sometimes to give something away: "Who is this?", "Is this some prankster?", "Is this on the level?", etc.

▲

EVEN before the winnings of their new contract are digested, the United Steel Workers have advanced new programs that include fewer work hours, continued "sharing of the wealth of American industry," improved welfare benefits and greater organization of clerical and technical workers.

At the same convention, the union boosted dues from $3 to $5 a month, a move not exactly favored by the rank-and-file members. And union officers got fat salary increases.

▲

SALES of materials handling equipment to the iron and steel industry will increase by at least 100 per cent during the next ten years, according to Roy Wolter of Automatic Transportation Co.

▲

AND it might well be remembered that the committee on political education of the AFL-CIO is staging an intensive campaign for contributions of one dollar each from the 16,000,000 members and for the enlistment of at least 2,000,000 political campaign workers.

▲

AN observant friend says that a boom period is when consumers are well enough off to live beyond their means.

▲

THREE closed electric low-shaft furnaces have been erected at the A/S Norsk Jernverk plant in Norway for electric smelting of Norwegian ores. Each furnace has a capacity of about 20,000 kw and a daily production of approximately 200 metric tons of pig iron. Hydro-electric power is supplied at 50 cycles. Capacitors are installed in connection with the furnace transformers for power correction. Power consumption and electrode consumption are said to be favorable, and the furnaces have, from the start, been working uniformly and without disturbances.

▲

A correspondent who ought to know tells us that a committee is a group that keeps minutes and wastes hours.

▲

THE proceedings of the First National Congress of the Siderurgical Industry of Mexico (held in Monterrey last October) have been published in a fine 440-page book. The book contains papers (in Spanish) on raw materials, material handling, economics, industrial relations, and steel plant equipment and operating problems. A number of men from the industry of the United States participated, including L. G. Levoy and R. E. Marrs of General Electric Co., F. H. Allison of Blaw-Knox Co., J. M. Dugan of Ohio Steel Foundry Co., C. W. Whiting of Whiting Corp., K. Oganowski of Armco Steel Corp. and A. J. Winchester of Westinghouse Electric Corp.

The Second National Congress is scheduled to be held in Vera Cruz, March 17-21, 1957.

▲

THE current campaigns lead one to believe that political fences are principally hedge.

▲

INDUSTRIES of the United States used 31,640 long tons of primary tin during the first half of 1956, more than in any corresponding period since 1950. Of this, 56 per cent was used for tin plate, 17 per cent for solder, 7.3 per cent for bronze and brass, 4.1 per cent for babbitt, and the remainder for tinning, white metal, collapsible tubes, chemicals, etc.

▲

DISCUSSIONS at a personnel conference held by the American Management Association pointed up the fact that industry is going to have to learn to live with a chronic manpower shortage. Among suggested remedies are better recruiting of new talent, both on the campus and among current employees; holding the people already in the organization by keeping salaries competitive; pooling of a company's engineers, draftsmen and technicians; thorough job analysis so that engineering aides and technicians can relieve engineers of routine duties; and, for longer range, stepping up the training of engineers and scientists.

▲

ONE-THIRD of the average family's income goes out in taxes, but many are hidden. Tax experts report 151 taxes on a loaf of bread, 100 on an egg, 116 on a man's suit, 150 on a woman's hat and 600 on a house.

▲

THE Wall Street Journal observes that anyone who missed out on a vacation trip can get the same feeling at home by tipping every third person you see.

▲

WESTINGHOUSE Electric Corp. spends approximately 10 per cent of its sales dollars for research, engineering and development, about two and one-half times the average of all industry.

SIR HENRY BESSEMER *concentrated on steel metallurgy when England needed cannons for the Crimean War. Steel was then being made from wrought iron by the slow, costly crucible method. He sought to produce it faster by blowing air through molten pig iron. His first attempt, in 1854, succeeded.*

But Bessemer's process required Swedish iron and could produce only high carbon steel. With English irons, it failed completely. For years, Bessemer tried to produce mild steel. The final solution came when manganese was added in the form of spiegeleisen, opening the door to the modern age of steel.

Great Names in Steel Making #III

When you look at Henry Bessemer's great achievement, two things stand out. First, his research was prompted by a critical war-time need. Second, his process was not perfected until freed from its dependence on imported iron.

Men familiar with modern rolling mill practice will note interesting points of similarity in the development of an all-American lubricant replacing palm oil.

The search for such a lubricant began during World War II, when the palm oil then indispensable for cold rolling had to be imported across submarine-infested oceans. Success came midway in the Korean War, when Ironsides engineers announced the perfecting of Palmoshield, "the palm tree that grows in Ohio."

Palmoshield ended, forever, our country's dangerous dependence on imported palm oil. Within six months of its appearance, two-thirds of our major tin plate mills were using or testing Palmoshield. In the four years since, its application has steadily broadened to the rolling of sheet, long terne and coating lines as well.

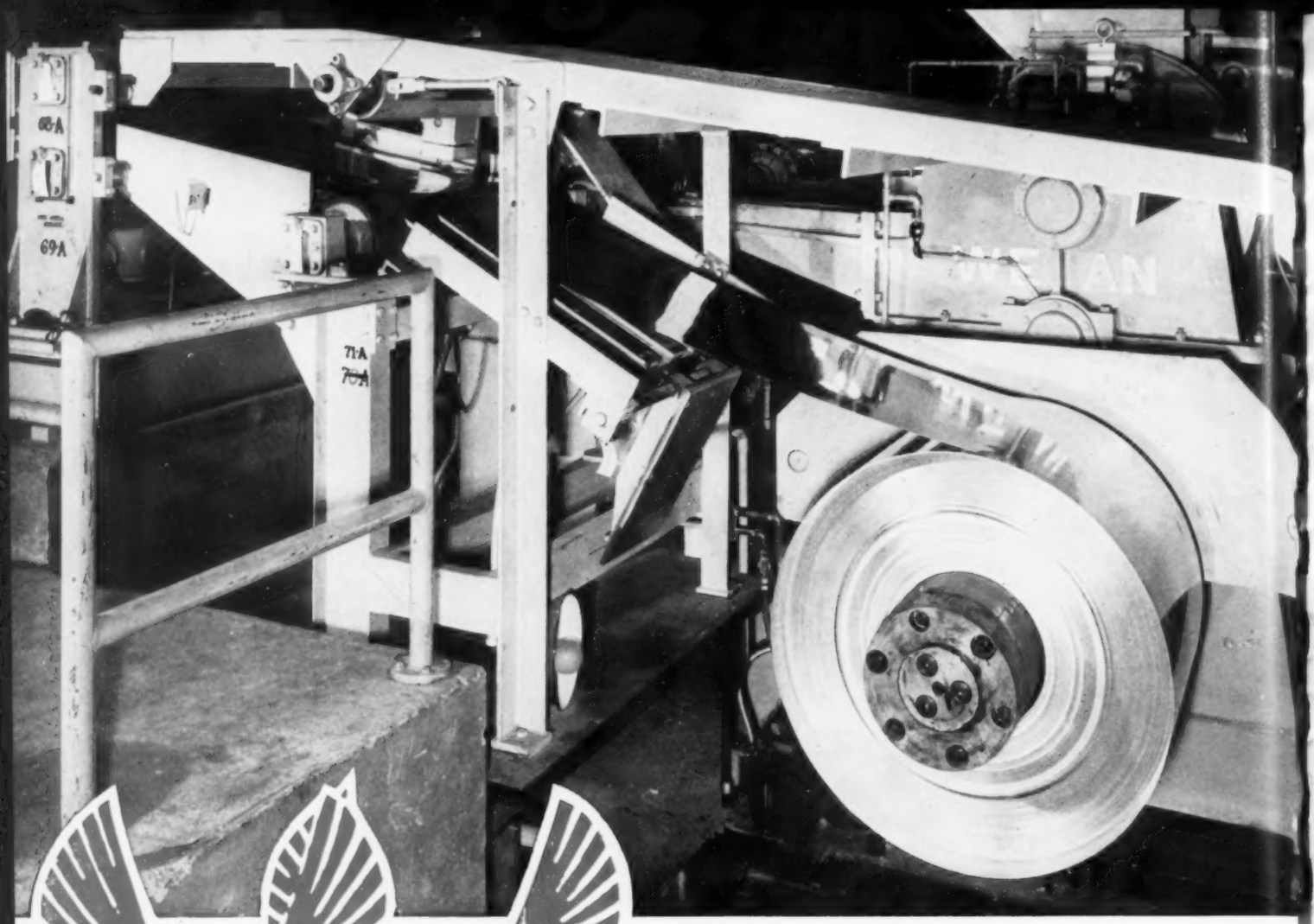
Palmoshield has every desirable characteristic of palm oil, but is compounded entirely of domestic materials. It need not be stockpiled. Fatty acid content can be controlled within ½%. Most gratifying of all, in mill after mill its use has resulted in increased production.

With few exceptions, major rolling mills today are either using Palmoshield, or have fully tested it in their production so as to be prepared to adopt it without changing their mill operation at any future time.

In the past four years, Ironsides engineers have successfully compounded Palmoshield for all different methods of application. They know how and stand ready to "custom tailor" Palmoshield for the particular method you employ. Their experience, and the advantages of an unfailing domestic source of supply, can both be yours through a letter or phone call addressed to The Ironsides Company, Columbus 16, Ohio.

By the makers of Palmoshield
"the palm tree that grows in Ohio"

JOSEPH MARGULIES.



WEAN

electrolytic tinning

The Wean Engineering Company is meeting today's demands for equipment to produce tin plate and zinc coated strip steel with light coatings by the electrolytic method; also equipment to produce chemically treated black plate and strip steel. Equipment for coating strip steel with zinc and other materials by the hot dip method is also available.

The WEAN ENGINEERING COMPANY, INC.

WARREN, OHIO

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Iron and Steel Engineer

OCTOBER, 1956 VOLUME XXXIII NUMBER X

In This Issue

Patent Reviews — By Melvin Nord, Patent Attorney, Detroit, Mich..... 21
Crops and Shorts..... 49
Power Requirements of Rolling Mills — By James H. Taylor, Chief Electrical Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.... 55
Effect of Finishing Temperatures on Properties of Hot Rolled Steel Plate — By R. H. Frazier, Assistant Chief, F. W. Boulger, Chief, Division of Ferrous Metallurgy and C. H. Lorig, Technical Director, Physical and Process Metallurgy, Battelle Memorial Institute, Columbus, Ohio... 67
Electric Drive Systems for Rod, Bar and Merchant Mills — By F. E. Fairman, III, Steel Mill Application Engineer, General Electric Co., Schenectady, N. Y., and A. C. Parsons, Steel Mill Engineering, General Electric Co., San Francisco, Calif..... 80
Additives in Steel Mill Lubricants — By M. S. Clark, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y..... 87
Developments in Steam Generating Units for Steel Plants — By F. S. Gilg, Executive Assistant, and Norman W. Young, Assistant Chief Staff Engineer, Boiler Division, The Babcock and Wilcox Co., New York, N. Y..... 94
Modernization of 44-In. Blooming Mill at J & L's Aliquippa Works — By A. B. Millman, Assistant Superintendent of Maintenance, Jones & Laughlin Steel Corp., Aliquippa, Pa..... 103
Continuous Annealing of Steel Plate Strip — By Horace Drever, President, Drever Co., Bethayres, Pa..... 109
Current AISE District Section Meeting Notices..... 111
Gear Tooth Forms for Steel Mills — By John J. Stolz, Assistant Vice President Engineering, Tool Steel Gear and Pinion Co., Cincinnati, Ohio 112
AISE Annual Convention — Pictorial Review..... 122
The Use of the Modern Assel Mill in the Production of Seamless Tubing — By Charles E. Snee, General Foreman, Assel Mill, The Timken Roller Bearing Co., Steel and Tube Division, Canton, Ohio..... 124
Contributions to Arc Furnace Operations — By L. A. Wynd, Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill..... 135
Electric Open Hearth Combustion Controls at Algoma — By A. K. Bayles, Chemical Engineer, and D. M. Stanton, Fuel Engineer, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada..... 143
AISE Kelly Award Winners..... 148
Russian Log — By Lee Wilson, Chairman, Lee Wilson Engineering Co., Cleveland, Ohio..... 150
Wire Coil Stripping Machine is Mechanically Activated..... 162
Card Programmed Control System Applied to Hot Strip Reversing Roughing Mill — By Andrew W. Smith, Metal Working Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa. 164
Westinghouse Dedicates New Research Laboratories..... 167
High Speed Quenching Oils Meet Broad Range of Heat Treating Requirements — By S. J. Barber, Manager of Metalworking Dept., E. F. Houghton & Co., Philadelphia, Pa..... 168
Date-line Diary..... 181
Industry News..... 191
Personnel News..... 209
Equipment News..... 233
Book Reviews..... 247
Index to Advertisers..... 263

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"We bought a 20-ton Lectromelt* Furnace for inventory control,"

says Rotary Electric Steel

Their five big furnaces run a minimum of 60 tons each

● 15 to 30-ton lots of stainless steels can be produced in a hurry in this new Lectromelt furnace. That enables Rotary Electric Steel Company of Detroit to offer prompt delivery when certain of these special steels are out of stock.

Precise quality control and constant checking of the steel at each processing step are basic in Rotary's production. The ease with which alloys can be adjusted and the speed with which Lectromelt furnaces can be put to work makes them well suited to these policies.

Lectromelt furnaces for melting and refining are described in Catalog 9-B. For a copy, write Lectromelt Furnace Company, 310 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).

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WHEN YOU MELT... *Lectromelt*

Power Requirements of Rolling Mills

By JAMES H. TAYLOR,

Chief Electrical Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

▲ MOST studies of the power requirements of rolling mills are today based to some extent on power curves which show the relation between hphr per ton thickness or elongation. The data from which these curves were made came from tests on actual rolling operations on various rolling mills, and consisted of recording the drive motor kilowatt input, speeds, thickness, widths, temperatures and analysis of the rolled material, nature and size of the rolls, and in some cases, roll pressures.

The author's company has conducted many such tests, rolling various metals on both hot and cold mills, and some of the power curves derived therefrom are shown in this paper under identifying captions.

Almost all of the curves shown exclude motor losses, but include both idle and load friction in the hphr per ton ordinate. Under test conditions, it is rather inconvenient to obtain a value for friction in the mill and drive bearings when the mill is under load. Idle friction power is easily obtained and can be deducted from the total power. However, on the average run of rolling mills today, the difference in friction between various roller bearing mills, either with or without gear reducers, is negligible and would not affect the calculations on power requirements to any appreciable extent. There is one type of rolling power calculations where the effect of bearing and roll friction does influence the resulting drive power. This is when power curves are used that are derived from tests on cold mills with fairly large diameter rolls rolling very light schedules of many passes, such as used on some thin tough alloys, where the actual power to reduce the metal is a very small percentage of the total power put into the drive. Most of this power may be in the deformation of the softer back-up rolls by the work rolls and in bearing and miscellaneous friction. This is evident in the curves for stainless steel and titanium (Figure 1 and Figure 2) where the slope of the curve is very great, almost a straight vertical line. When using these curves to obtain the capacity of the drive motor for mills of much smaller work roll diameter rolling thin and tough alloys, it is necessary to make some deduction for the smaller work roll size, otherwise the calculated drive power required will be very excessive. On work roll driven mills of fairly small roll diameters, the stress on the roll necks or spindles must also be investigated, for this stress alone sometimes limits the size of the drive power that can be applied. The subject of rolling thin gages with various diameter rolls is a treatise in itself, and admittedly, there are more exact methods of obtaining the required drive power under these conditions. For a detailed analysis, the writer would refer to a paper presented to the AISE on September 15, 1955, by Dr. M. D. Stone of our company. (*Editor's Note: This will be published in a future issue of the Iron and Steel Engineer.)*

The formula hp=K × hphr per ton × leaving thickness and width × roll feet per minute is used to obtain the power curve from the recorded test data. It is, of course, also used in calculating the drive power required to reduce the metal. The constant K is 0.102 for steel, 0.035 for aluminum, and 0.110 for brass. Its value is determined by the weight of the particular metal.

At one time before hot mill power curves were as well established as they are today, the method of calculating the drive power required was based on the compression resistance of the metal, the compression rate, and the projected contact area to obtain separating force; the separating force multiplied by a lever arm of ½ the projected contact length gave rolling

. . . . theoretical determinations of power required for rolling metals are not only complicated but oftentimes inaccurate . . . . therefore, the best method for determining power requirements of new mills is based on actual power data on existing mills which are similar to the one being considered and which are rolling materials of the same kind and size as that for which the new mill is intended . . . . careful analysis of such data can lead to very accurate results . . . .

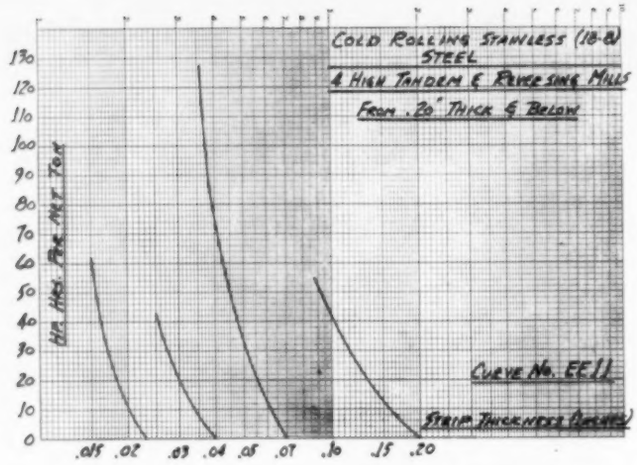


Figure 1 — Curves give power required to cold roll 18-8 stainless on 4-high tandem and reversing mills.

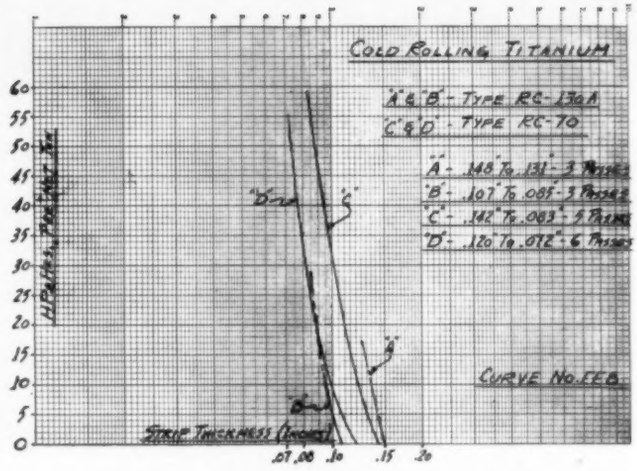

COLD ROLLING TITANIUM
"A" & "B" - TYPE RC-130A
"C" & "D" - TYPE RC-70
"A" - .148" TO .131" - 3 PASSES
"B" - .107" TO .085" - 3 PASSES
"C" - .142" TO .083" - 5 PASSES
"D" - .120" TO .072" - 6 PASSES
CURVE NO. EE8
STRIP THICKNESS (INCHES)

Figure 2 — Curves give power required to cold roll titanium.

torque per roll. To this value additional torque was added to make the total torque include friction. This method of power calculation is obviously much more time consuming than using a power curve and the above formula, and the accuracy of the result is certainly no greater if the proper power curve is used. There was also another method used for computing power to cold roll metal and that was based on pressure curves put out by a roller bearing company and the use of a roll pressure lever arm of ½ the projected contact length. This also required more calculations than the power curve method, and its accuracy was certainly no better. The use of a lever arm of ½ the projected contact length is not necessarily true for all conditions of rolling. In fact, we ran a test on the hot rolling of both mild steel and stainless steel some years ago. We put pressure meters on the housing posts and from the pressures and motor torques obtained, we found that the lever arm varied from about 0.25 to 0.85 of the projected contact length.

Power curves for hot and cold strip mills are generally shown with the horizontal ordinate in thickness of the material while curves for rod mills, slab mills and structural mills have elongation as this ordinate. Curves for the hot and cold strip mills can very well be drawn to show thickness instead of elongation, and it is quite often an advantage to do so. The use of one power curve based on elongation and used for determining the rolling power when reducing from almost any starting thickness to a minimum finishing thickness is

Figure 3 — Curve gives power required for hot rolling mild steel on slabbing and blooming mills.

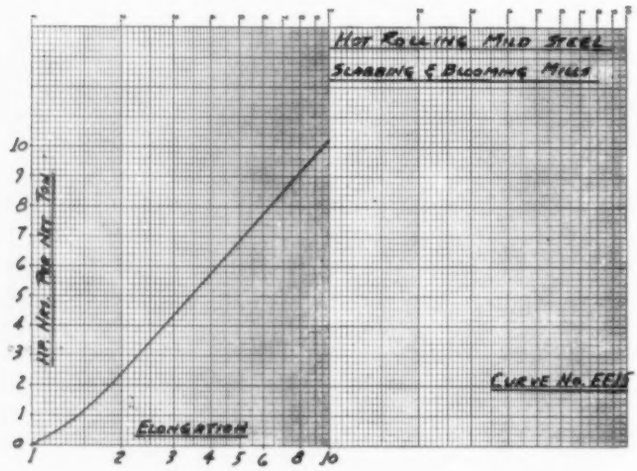


TABLE I

Mild Steel Slab Mill Rolling Schedules

Slab mill with edger

Ingot size: 27 x 57 in.
Ingot weight: 29,000 lb

Pass No.	Horizontal roll opening, in.	Edger opening, in.
1	54	....
2	25*	54½
3	22¾	54¾
4	21	54¾
5	18⅞	54¾
6	17	54¾
7	15	54¾
8	13	54¾
9	11	54¾
10	9	54½
11	7⅞	54½
12	6¾	54
13	5½	54
14	5	54

*Turned after pass No. 1.

Slab mill without edger

Ingot size: 29 x 57 in.
Ingot weight: 28,000 lb

Pass No.	Horizontal roll opening, in.	Pass No.	Horizontal roll opening, in.
1	56¼	10	50**
2	54	11	10½
3	24⅝*	12	8⅞
4	21⅞	13	7½
5	19½	14	5⅞
6	17⅛	15	51**
7	14⅜	16	....
8	12	17	5
9	51⅜**		

*Turned after pass No. 2.
**Edging pass.

not advisable. Unfortunately, the present state of our power curves for slab, rod and structural mills has not definitely shown a difference in power to roll from various sizes of ingot, bloom or billet to the respective minimum size slab, structural shape or rod. In other words, one curve for each mill appears to take care of all total elongations from any practical size of the heated material to any practical size of the finished product.

SLABBING MILLS

Figure 3 applies to a power curve for slab and blooming mill rolling. This curve can be used equally as well for universal slab mills. Tests have indicated that there is little difference between the two mills relative to reduction power requirements. To determine the motor size of the slabbing mill drive, the rate of production, the ingot and final slab sizes and chemical analysis must, of course, be known. Following general rolling practice, a schedule is made up showing the number of passes and the size of the ingot after each pass. Rolling schedules for a slabbing mill with attached edger and without edger are shown in Table I.

By use of the formula hp=0.102 $\times$ hphr per ton per pass $\times$ leaving area $\times$ roll fpm converted to torque; that is roll torque T=140 $\times$ hphr per ton per pass $\times$ area $\times$ roll diameter, the rolling torque including friction is calculated for each pass. It is necessary to check the rolling schedule for the value of the bite angle in each pass. This is the angle the sine of which is the projected contact length divided by the roll radius. This varies with the roll diameter and the amount of reduction. A figure that is used for a maximum bite angle on fairly smooth slab mill rolls is 20 degrees and when the rolls are ragged, the bite angle is in the neighborhood of 30 degrees. Generally the ingot is entered between the mill rolls running close to base speed and then accelerated to base speed or somewhat higher. The torque required for this acceleration must be supplied by the motor, and it is determined by the well known formula:

$$\text{Average torque} = \frac{WR^2 \times \text{rpm.}}{308 \times \text{time}}$$

The total motor torque is the sum of the rolling torque and accelerating torque and should lie at or below the frequently repeated overload torque of the motor at the shunt field speed of the pass. Based on a momentary overload, the motor capacity can thus be determined, however from a heating standpoint, it is possible that the motor selected from the momentary overload is too small in continuous capacity. Based on a theoretical 300 tons per hour rolling rate on the average product, practice has indicated that a motor whose capacity is determined by its frequently repeated torque in relation to the required torque per pass on present day rolling schedules is satisfactory from a heating standpoint or RMS duty. The twin 5000-hp, 40/80-rpm motors appear to be satisfactory in size to take a maximum reduction of 3½ to 4½ in. on ordinary open hearth steel ingots under about 35 in. in width and about 2 to 3 in. on ingots of wider size. Some 5 in. has been taken off in one pass on 28 in. wide ingots.

Obviously these maximum reductions depend on the type of steel and the temperature. If the steel is tough and the temperature is low, the maximum reductions may be 3 in. on ingots 35 in. wide and under and 2 in. on wider ingots. If the ingot is well heated to about 2300 F, little delay is experienced due to any limitations in reduction. It is not always the capacity of the motor that limits the reduction, for quite often the rolling schedule must be so arranged to take more passes to effect a certain overall reduction than is necessary from a motor capacity standpoint in order that the rolled ingot will remain fairly square at the edges and for other reasons. If the ingot temperature is not high enough due to the ingot not remaining in the soaking pits a suitable length of time, the rolling power requirements may demand all or more than the 5000-hp motors can give. It may not be economical to increase the two 5000-hp motor sizes just to take care of malpractice in the soaking pits. The partial tandem rolling of ingots to slabs which is being done in some mills increases the required continuous capacity of the motor. The two 5000-hp motors will overheat if this practice is continued for some period of time.

The application of two 6000-hp, 40-rpm base speed motors now on or proposed for latest slab mills provides this RMS duty and permits more leeway in the rolling of especially tough ingots and those that are not quite up to temperature. On 45-in. slabbing mills with 36-in. diam attached edgers, the latest installations have 4000-hp, double armature, 60/150-rpm motors on the attached edger. The older mills had 3000-hp, 60/180-rpm, and it is recognized that they are somewhat underpowered relative to torque at the edger rolls. Unfortunately, the older mills had no separate generators on their edger motors, and the edger shunt field range and gearing had to be such to synchronize with the horizontal mill speed range, ranges in roll diameters, and mill reductions. The shunt field range of the edger motors, therefore, had to be more than 2 to 1. Had separate generators been provided with a lower motor shunt field range and lower gear ratio, greater overload torque at the rolls could have been realized with the same edger drive motors.

All universal slab mills installed during the past eight years or so have separate generators on their attached edger motors. Not in every case has full advantage of a separate edger generator been taken. This advantage lies in the possibility of reducing the edger motor weakened field speed and lowering the gear ratio to obtain greater available torque at the rolls. At first thought, lowering the gear ratio would appear to reduce the available roll torque. However, based on standard frequently repeated motor torque curves, the available motor torque capacity is reduced greater by weakening the motor shunt field than by lowering the gear ratio. When acceleration torque is considered, there is a second advantage to a lower gear ratio and shunt field speed. The 4000-hp motor has a WR^2 about 60 to 70 per cent greater than the edger. Also, the change in edger WR^2 with change in gear ratio is small. Hence the total WR^2 of both motor and edger does not change appreciably with change in gear ratio. In view of this and the fact that the shunt field speed does decrease directly with a

decrease in gear ratio for the same fpm, it follows that the acceleration torque becomes less with lower gear ratio. Since acceleration torque is less and the lower shunt field speed setting provides greater torque capacity; the per cent full load acceleration torque is also improved.

Reference to Table II, which is a slab mill edger torque comparison, will indicate the effect of gear ratio in the roll torque and per cent full load accelerating torque. Incidentally, the values for per cent accelerating torque shown in the calculations are only relative values for they have been based on a full load motor torque at the shunt field speed to which the edger is accelerated, rather than based on an available torque average of full field and weak field. Also, the edger roll fpm is made the same as the horizontal mill. In one direction of rolling, the effect of a lower edger rpm due to reduction in the horizontal mill may lower the accelerating torque. However, this is not considered in the comparison since about the same roll torque is also required in the pass of opposite direction.

The two rows of figures, Mill D, in the torque illustration are those for a slab mill of the era when both edger and horizontal mill were on a common bus arrangement of generators. When the available motor torques at the rolls less acceleration torque based on two sec reversal time are compared with later mills such as B and C with even 1½ sec reversal—but based on the same motor capacity—the adverse effect of the common bus can be seen. Should one discount acceleration and compare only the net torque at the rolls, there is still a gain of about 10 per cent in the use of separate generators. To obtain greater torque at the rolls, these older mills had to reduce their acceleration torques by increasing the time of reversal considerably.

Mill A compensates for edger and horizontal mill roll diameters and mill reduction by edger generator voltage, while mill B compensates for horizontal mill roll diameter and mill reduction by edger voltage and edger roll diameters by edger motor shunt field. Due to mechanical reasons, it is better to have a higher gear ratio than 1.06 to 1. Therefore, it is believed that a slabbing mill with an edger gear ratio in the vicinity of 1.16 to 1 and an edger motor 4000-hp, double-armature, 60-rpm, base speed with a shunt field range sufficient to handle the full shunt field range of the horizontal mill motor plus edger roll diameter range and possibly a few per cent extra range would be the correct drive. It should be noted from Table II, mill E, that an edger drive consisting of a 4000-hp, 80/185-rpm, increases roll torque and reduces per cent acceleration torque from that shown for mill C with same gear ratio of 1.54/1. It can also be seen from Table II that mills C and D are limited in top slab mill speed. Admittedly this may not be too great an objection on strictly slabbing mills for very few mills use 80-rpm, and when they do, it is only on the last few passes.

The standard setup today among the electrical

TABLE II

Comparison of Slab Mill Edger Available Torques

Mill	Horizontal mill 45 in. diam roll		Edger — 36 in. roll									
	Rpm	Fpm	Gear ratio	Motor rpm	Fpm	Total WR^2	Average accelerating torque at motor	Maximum frequently repeated torque at motor	Maximum frequently repeated torque at rolls less accelerating torque	Maximum frequently repeated torque at rolls no acceleration	Full load torque at rpm	Per cent full load accelerating torque
A	40	473	1.06	53.3	473	922,300	200,000	790,000	625,000	836,000	351,000	57
	40	473	1.06	58.4	473 (33 in. diam)	922,300	218,000	790,000	605,000	836,000	350,000	62.3
	40	452 (43 in. diam)	1.06	55.6	452 (33 in. diam)	922,300	209,000	790,000	615,000	836,000		
	70	825	1.06	93	825	922,300	174,000	455,000	298,000	482,000	228,000	76.3
B	40	473	1.16	58.2	473	904,000	214,000	790,000	670,000	915,000	350,000	61.2
	40	473	1.16	63.8	473 (33 in. diam)	904,000	234,000	683,000	520,000	790,000	332,000	70.5
	40	452 (43 in. diam)	1.16	60.9	452 (33 in. diam)	904,000	223,000	733,000	590,000	850,000		
	70	825	1.16	102	825	904,000	187,000	403,000	251,000	467,000	206,000	90.7
C	40	473	1.54	77	473	852,700	266,000	560,000	453,000	860,000	266,000	100
	70	825	1.54	135	825	852,700	233,000	287,000	83,000	443,000	157,000	148
D	40	473	2.04	102	473	707,000	220,000	302,000	167,000	616,000	157,000	140
	70	825	2.04	179	825	707,000	152,000	145,000	—	296,000	84,000	180
	Mill A: 4000 hp, 60/130 rpm, 1.5 sec base to base Mill B: 4000 hp, 60/140 rpm, 1.5 sec base to base Mill C: 4000 hp, 60/150 rpm, 1.5 sec base to base Mill D: 3000 hp, 60/180 rpm, 2 sec base to base				Mill C with a 4000-hp, double-armature, 80/185 rpm motor							
E	40	473	1.54	77	473	717,000	224,000	593,000	568,000	913,000	263,000	89
	70	825	1.54	135	825	717,000	196,000	302,000	163,000	465,000	157,000	125

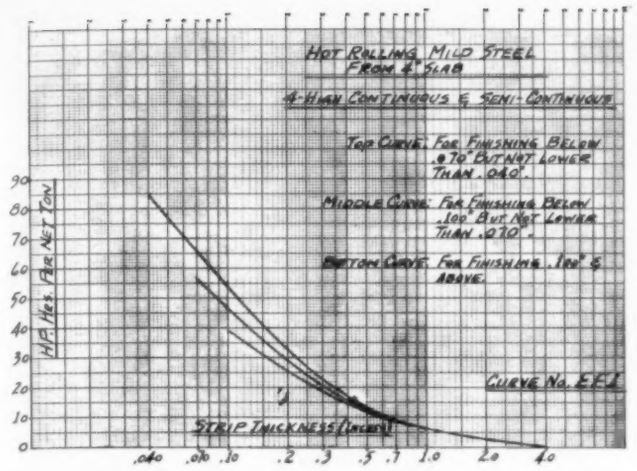

HOT ROLLING MILD STEEL FROM 4" SLAB
4-HIGH CONTINUOUS & SEMI-CONTINUOUS
TOP CURVE: FOR FINISHING BELOW .070" BUT NOT LOWER THAN .040".
MIDDLE CURVE: FOR FINISHING BELOW .100" BUT NOT LOWER THAN .070".
BOTTOM CURVE: FOR FINISHING .100" & ABOVE.
H.P. HRS. PER NET TON
STRIP THICKNESS (INCHES)
CURVE NO. EE-1

Figure 4 — Curves give power required to hot roll mild steel from 4-in. slabs.

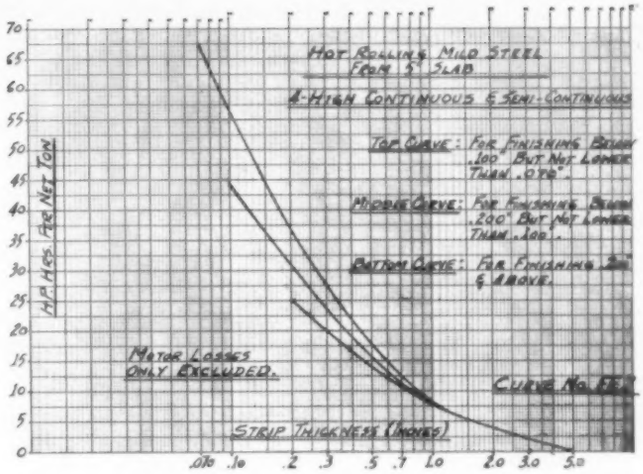

HOT ROLLING MILD STEEL FROM 5" SLAB
4-HIGH CONTINUOUS & SEMI-CONTINUOUS
TOP CURVE: FOR FINISHING BELOW .100" BUT NOT LOWER THAN .070".
MIDDLE CURVE: FOR FINISHING BELOW .200" BUT NOT LOWER THAN .100".
BOTTOM CURVE: FOR FINISHING .200" & ABOVE.
MOTOR LOSSES ONLY EXCLUDED.
H.P. HRS. PER NET TON
STRIP THICKNESS (INCHES)
CURVE NO. EE-2

Figure 5 — Curves give power required to hot roll mild steel from 5-in. slabs.

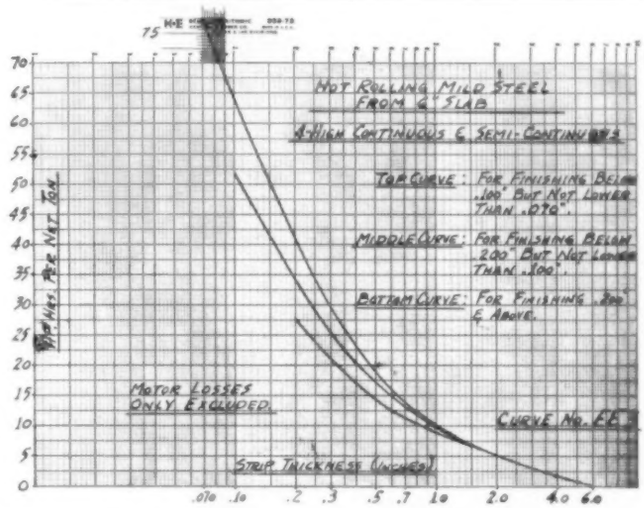

HOT ROLLING MILD STEEL FROM 6" SLAB
4-HIGH CONTINUOUS & SEMI-CONTINUOUS
TOP CURVE: FOR FINISHING BELOW .100" BUT NOT LOWER THAN .070".
MIDDLE CURVE: FOR FINISHING BELOW .200" BUT NOT LOWER THAN .100".
BOTTOM CURVE: FOR FINISHING .200" & ABOVE.
MOTOR LOSSES ONLY EXCLUDED.
H.P. HRS. PER NET TON
STRIP THICKNESS (INCHES)
CURVE NO. EE-3

Figure 6 — Curves give power required to hot roll mild steel from 6-in. slabs.

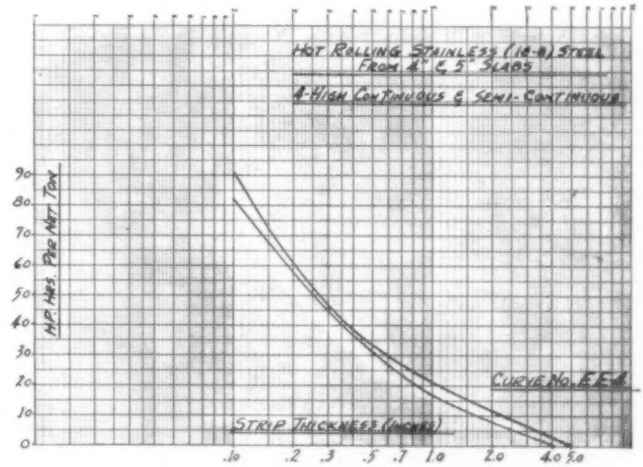

HOT ROLLING STAINLESS (18-8) STEEL FROM 4" & 5" SLABS
4-HIGH CONTINUOUS & SEMI-CONTINUOUS
H.P. HRS. PER NET TON
STRIP THICKNESS (INCHES)
CURVE NO. EE-4

Figure 7 — Curves give power required to hot roll 18-8 stainless from 4 and 5-in. slabs.

manufacturers is for motors, generators, and control on a slabbing mill to be such as to permit a 1½ second reversal time from 40 to 40 rpm. Not so long ago the electrical equipment was furnished on a two-second reversal time. The modification in equipment to achieve better than 1½ or 1 second reversal is somewhat expensive, and it appears questionable if the gain in production warrants the additional expense. While one would not, it is believed, recommend today a reversal time in excess of 1½ or 2 seconds, there is a 45-in. universal slabbing mill now obtaining an average production of 3400 tons per turn (it also has the world's record for maximum eight-hour and monthly production) with about six seconds reversal time. Since this mill is a universal, its time of reversal should be more influential in production than on a slabbing mill without attached edger. This reasoning is, of course, based on the fact that there is less slab handling on a universal slab mill than on a high lift slabbing mill without edger.

HOT STRIP MILLS

Referring to power curves, Figures 4, 5 and 6, showing the hphr per ton to reduce mild steel slabs starting at 4, 5 and 6 in., you will note that the curves branch out at some indefinite point from the starting thickness. As the finished gage becomes smaller when rolling from the same size slab, the slope of the power curve increases. This means that for a strip finishing thickness of say 0.080 in. more relative power would be required to reduce the material from a 6-in. slab than from a 4-in. slab, as can be seen by comparing Figures 6 and 4. This also shows up in the reductions from a given slab thickness. That is, on a reduction of 0.3 to 0.2 in., the top curve would give 11 hphr per ton, the middle curve 8½, and the bottom curve 6½. This is due to a group of factors, two of which are probably rate of compression and temperature. Although only three branches are shown on each figure, actually the curve should indicate many branches. These curves apply about as well to either continuous or semi-continuous mills. Figure 7 is a power curve for hot rolling 18-8 stainless. It could be assumed that these curves should branch out similar to those for mild steel. However, we have not been able to accumulate enough data to determine this primarily because of the limited range in stainless schedules compared with mild steel. Figure 8 represents power curves for the hot rolling of 70-30 brass. Figure 9 shows power curves for the hot rolling of aluminum alloys. Reductions from reheated aluminum alloy slabs (700 to 800 F) to finished gages are as given in Table III.

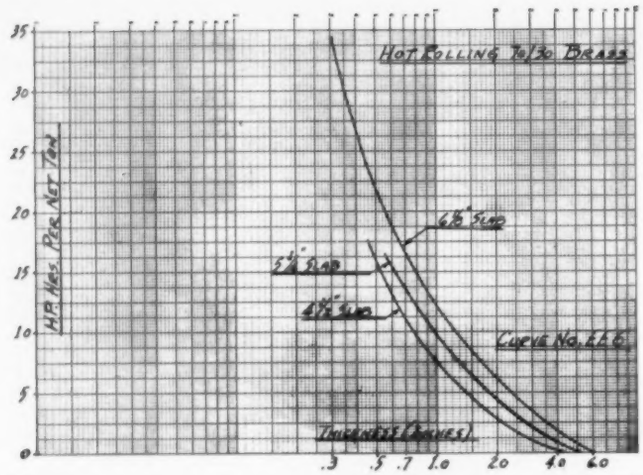


Figure 8 — Curves give power required to hot roll 70/30 brass from 4½, 5½ and 6⅛-in. slabs.

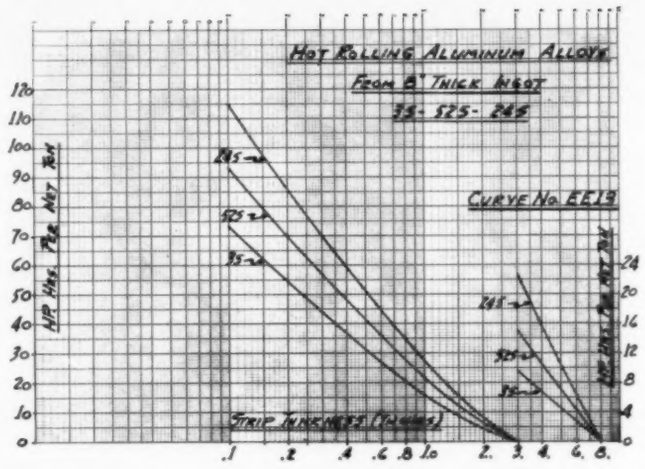


Figure 9 — Curves give power required to hot roll soft aluminum alloys from 8-in. thick ingots.

TABLE III

Hard Alloys	Soft Alloys	
Starting 3.6	Starting 3.3	Reversing mill
2.6	2.25	
2.0	1.5	
1.5	1.0	
1.00		
0.75		
0.381	0.365	5-Stand
0.251	0.235	finishing
0.151	0.135	train
0.101	0.085	
0.091	0.075	

Generally the hard alloys are brought to the finishing train at 0.75 in. thick and the soft alloys at 1.00 in. thick regardless of width. Rolling speeds are about one-third the speeds of the hot strip steel mill, yet the stand motor capacities are comparable.

The same method of calculating the rolling hp from the power curves is used for the hot strip mill. Maximum and minimum finishing gages and maximum and minimum slab sizes must be known. Rolling schedules are then made up following reasonable rolling practice relative to reductions in each stand and also to the ever-present bite angle. Values that are used for this angle are 16 degrees for smooth rolls, no pusher, 24 degrees with pusher and 19 degrees with edger. With a-c motor roughing stands, it is necessary when making the power calculations to check the proposed or existing length of tables between stands with the lengths of the slab after it is reduced in thickness in each stand. Some of the hot strip mills which today are modifying their roughing stand drives to roll a larger slab either in thickness or length or both, have found that existing centerline distance between their stands limits the maximum size slab and also the maximum drive power that should be applied to the stands. On new installations, after the power calculations are completed, the motor capacity can be initially selected from the rolling power based on about 175 to 200 per cent load for the roughers, and about 140 to 150 per cent for the finishing stands.

Usually the roughing stand motor capacities when selected on basis of 175 or 200 per cent load to roll the heaviest schedule will have an rms duty about equal to or less than their continuous capacity. The finishing train motors, however, usually have an rms duty that is considerably higher than the roughers since the strip is in each finishing stand much longer than in each roughing stand. While cobbles, roll changes, and other downtime will reduce the tonnage output below the theoretical output calculated from the weight of the slab, time between slabs and time the slab is in the stand, the rms duty over a 2-hour period does not necessarily reduce due to those factors. Therefore, the continuous duty should be obtained from the theoretical output and using about 20 seconds between slabs. On continuous hot strip mills which roll or intend to roll 7 or 8-in. thick slabs, 25 feet long, to 0.080 in. gage with an average net tonnage of about 2500 tons per turn, the 2-hr rms duty of the finishing stand motor can reach 125 per cent of rated full load when the rolling loads are 150 per cent of full load. Since finishing stand motors generally are rated 40 C rise, self-ventilated, their full load rating is increased somewhat when they are forced-ventilated. This will, in effect, lower the rms, 2-hr duty on the motor somewhat below 125 per cent, but not enough to permit stand rolling loads of 150 per cent. It is the writer's opinion that from an rms duty standpoint, the peak motor loads rolling large slabs for long periods every day should not be more than 140 per cent full load and preferably less. This figure can be a little high when low inertia motors, which may be rated on a forced-ventilated basis, are to be used on the finishing train.

Today all of the roughing stands, except perhaps the broadside mill, if such is provided, would be driven by synchronous motors with pullout torques of 300 to 350 per cent full load. Pass times have become greater due to the larger slabs rolled, and this diminishes the benefit of the much more expensive wound rotor motors with flywheels. Although flywheels on the drives might on short passes roll comparatively cold slabs better than a synchronous motor drive of reasonable size, they can on maloperation of the screwdowns, which permits the slab to enter mill only a very small distance, put more energy into the drive than the synchronous motor and thus tend to cause greater damage to the mill.

The finishing stand motors generally have a standard frequently applied overload capacity of 160 per cent at

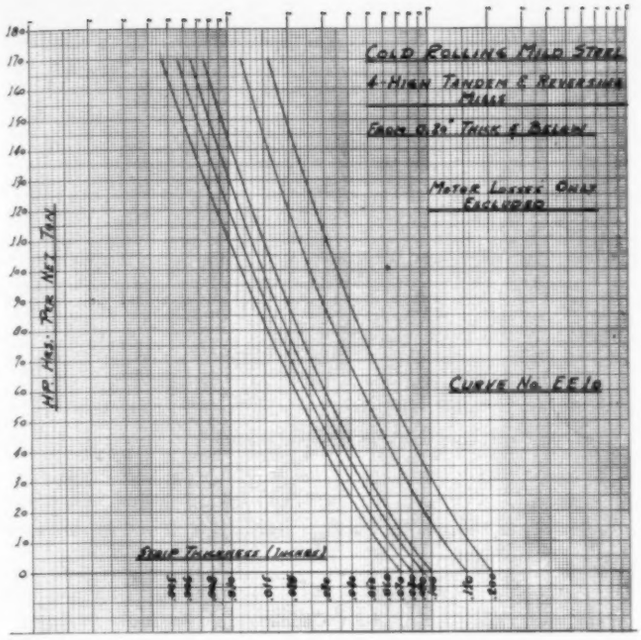

COLD ROLLING MILD STEEL
4-HIGH TANDEM & REVERSING MILLS
FROM 0.30" THICK & BELOW
MOTOR LOSSES ONLY EXCLUDED
CURVE NO. EE 10
HP HRS. PER NET TON
STRIP THICKNESS (INCHES)

Figure 10 — Curves give power required to cold roll mild steel on 4-high tandem and reversing mills.

twice base speed. To roll a few schedules with limited tonnage may make it advisable and economical to increase this overload capacity to 187 per cent at weak field, and 200 per cent at full field, rather than increase the motors' continuous capacity. The motor speed ranges on each stand of the finishing train should be selected to permit rolling practically all schedules in the shunt field range of the motor. If for other reasons, the power supply (generators or rectifiers) furnishing power to the stand motors is broken up into individual units or a partial common bus, then, of course, some of the schedules lying outside of a reasonable shunt field range can be rolled by reduction in the voltage applied to one or more of the stand motors, provided the load torque will permit. After a tentative motor selection is obtained, reference is made to existing hot strip mills of the same or nearly the same width. This reference compares the motor capacities of the various mills with the proposed mill and some readjustment of the motor capacity may result. Generally the motor capacity, as determined by the power calculations, serves only as a starting point. The final motor sizes selected are quite often larger in either continuous or overload capacity or both. Even with this procedure which results in motor capacities sometimes well above the requirements of the day, future requirements on the same mill have found these motors somewhat undersize. Of all the strip mills, the continuous hot strip mill has had the least concern with maximum acceleration and deceleration rates of the drives. It was, and is, of course, always desirable to have a minimum deceleration time in the event of cobble in the finishing train, but it is doubtful if any drive motor on the finishing stands has been increased in capacity purely on the basis of decelerating time. Today, the drive motor characteristics are being altered to give lower WK^2 and the control rapid response to give better correction in gage. This will also give faster deceleration time which is desirable.

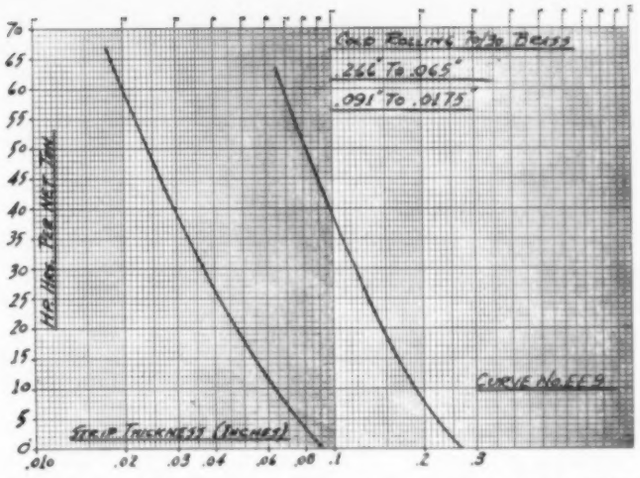


Figure 11 — Curves give power required to cold roll 70/30 brass.

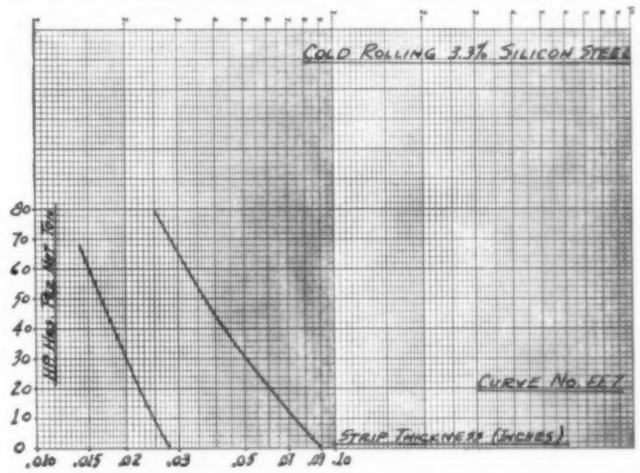


Figure 12 — Curves give power required to cold roll 3.3 per cent silicon steel.

TANDEM COLD STRIP MILLS

The calculation of rolling powers for the tandem cold strip mill follows almost the same method used for the hot strip mill. Cold rolling power curves such as seen in Figures 10, 11 and 12 for mild steel, brass, and silicon respectively give when adjusted for roll diameter hp-hr per ton per pass for each reduction in thickness as set up by the proposed rolling schedule. The hp obtained from each value of hphr per ton is the power to reduce the metal without the assistance of tension between stands and between the winding reel and the last stand. Tandem cold mills, of course, differ from the hot strip mill with respect to interstand tensions. Although tensions do exist to some extent in a hot strip mill finishing train, their presence is only desired to keep the strip flat and thus their effect on stand motor requirements is more or less negligible. When computing power requirements on a tandem cold mill, the difference between the front and back tensions on each stand converted to hp must be added or subtracted to the power obtained from the power curve for that stand. The tension in pounds pull generally decreases as the strip travels from the first stand to the winding reel. Fairly representative tensions between stands are given in Table IV.

TABLE IV

	3 Stand	4 Stand	5 Stand
Between stands 1 and 2	12,000 psi	12,000 psi	22,000 psi
Between stands 2 and 3	15,000 psi	15,000 psi	25,000 psi
Between stands 3 and 4	.....	8,000 psi sheet gages	28,000 psi
Between stands 4 and 5	.....	15,000 for tinplate	30,000 psi
Winding reel	8,000 psi	7,000 psi	15,000 psi

After the stand rolling loads are calculated from the rolling schedules and adjusted for tension, the values are plotted on a graph of a tentatively selected motor hp-speed curve. This graph is used more as a matter of convenience than anything else. All plotted values of rolling hp should be within the motor hp-speed curve. If only a few of the hp values are above the curve, and they are on schedules to be rolled only occasionally and with limited production, it may be economically advisable to lower the strip speed if possible rather than increase the motor hp. It is not often wise to rely on a higher motor temperature rise such as 50 or 55 C to roll the few odd schedules. The motor overload possibilities should be reserved for future requirements that cannot be envisaged initially. It is also advisable to check the stand loads when the strip is threaded through the mill. Sometimes stand No. 1 may have considerable motor overload before tension is applied between stands No. 1 and No. 2. This overload should be limited to about 160 per cent full load. All rolling schedules are plotted on a graph showing roll speed in fpm with respect to the stands. From this family of lines a speed envelope can be determined which will give the maximum and minimum speeds of each stand and in turn the motor shunt field range and base speed. Either or both the base speed and shunt field range may have to be modified from that determined by the cone or envelope if the speed range is too large or the base speed not satisfactory.

Since individual stand generators are now used on tandem cold mills, the stand motor voltage can be reduced to permit certain few schedules to be rolled without extending the motor shunt field speed range beyond a reasonable amount. If the mill speed is low enough to require gear reducers on some or all of the stands, the gear ratio can usually be made to fit an economical and practical motor base speed. After the motor hp and speed range have been tentatively selected, it is necessary to check the manufacturer's catalogue design of shunt field speeds and armature inertia. It is possible that this check will indicate the need for multiple armature construction both with respect to motor shunt field range and acceleration rate. Increasing the actual motor hp to improve acceleration is not often done since the hp selected for supplying the rolling load generally gives satisfactory acceleration time. Duplication of motors is always desired to reduce the number of spare armatures. Hence a final check of the motor capacities should be made to determine if any of the stand motors can be duplicated. Sometimes, if one is not careful, this duplication can be carried too far, and the cost of the duplication can well exceed the cost of an additional armature. It is also advisable to select motors with standard design base speeds whenever possible since sometimes the cost of a motor with a nonstandard base speed is higher than a motor with a standard base speed or conversely if the design shunt field range will permit, there may be no extra cost by lowering the odd base speed to the next lower standard speed with the possible additional advantage of extending the motor shunt field range. The types of tandem mill drives are many and for each type there are advantages and disadvantages. The work roll-pinion stand type of drive with single, double or triple-motor armatures is still acceptable to the steel industry. There are many tandem mills, however, that do not use a pinion stand, but drive directly from the motors to the work rolls. Some of these mills actually make use of the inherent possibility of these drives for mismatching top and bottom work roll loads while many others do not. In either case, the quality of the rolled metal and the tonnage obtainable is about the same.

REVERSING MILLS

Power curves resulting from tests made on reversing mills follow closely those for tandem cold mills. Consequently, the same power curves are used for both types of mills. One would assume that these curves should be about identical for the same total reduction. This, of course, ignores any comparison of the effects of the two different rolling oils. Front and back reel tensions on the reversing mill can be assumed to give about the same effect relative to reduction and power as those on the stands of the tandem mill.

As in the calculations for determining motor capacity of each stand of the tandem mill, the difference in front and back tension must be added or subtracted

TABLE V

2-Stand temper mill					
1.8	3.5	3.0	5.0	3.5	2.3
Uncoiler	Entry tension	No. 1 stand	No. 2 stand	Delivery tension	Reel
Single stand temper mill (coils)					
3.5	3.5	3.9	....	3.5	6.0
Single stand temper mill (sheets)					
1.8	....	6.5	....	....	2.3

to the power required for reducing the metal in the roll stand.

Since top speeds of reversing mills are in the vicinity of 1600 fpm, the problem of acceleration time is not nearly as difficult as in most other cold mills.

TEMPER MILLS

One of the most difficult mills to determine drive motor capacity as closely as the other types of cold mills is the temper mill. It is doubtful if any two mills, or even any two operators, follow exactly the same procedure in temper rolling. The author's company has conducted tests on many temper mills, and the data obtained varies considerably. We have not as yet found a reliable formula that would correlate tempers, flatness and strip surface quality with drive power.

About all we can do is to strike an average of all the mill power data we have obtained and use this average for the initial determination of motor capacities for a proposed mill. This so-called average is in the form of hp per in. of width per 1000 fpm and is applied to all stands, tension units and reels.

The hp per in. values for this unit are given in Table V.

When the ultimate user of the mill advises the exact nature of his own temper rolling practice including maximum and minimum tension, the problem of applying more nearly correct motor sizes is made easier. However, if it were possible to calcufate the correct rolling power on a temper mill, the actual power required on the mill is invariably much higher. This is caused by the need for as high an acceleration rate as possible. At present this rate appears to be about 250 to 300 fpm per second. Since on temper mills the inertia of the mill stands relative to the motor torque required for the rolling load is much higher than on a cold reduction mill, it follows that the temper mill motor capacity must be increased to obtain the acceleration whereas the motor capacity on a cold reduction mill generally does not. Even a multiple-armature motor construction does not usually provide the desired acceleration rate to the same extent as it does in the cold reduction mill. When the mill speeds are higher, the effect of the acceleration rate in determining the motor capacity is, of course, greater. The above applies mainly to the stand motors. Tension unit motors are not usually affected by the acceleration rate. The reels, however, are influenced by multiple armature construction, and their power requirements with reference to acceleration follow those on the cold reduction mills.

The increased motor capacity to obtain the acceleration rate is in the form of increasing the motor horsepower or its frequently repeated overload rating or both. When temper mills are used only for tin plate rolling, the need for increased motor torque at lower speeds is not considered sufficient to provide adjustable speed stand motors. So-called constant speed motors with only a small shunt field range for roll diameter variation can be used, and all operating speeds are obtained by changing motor voltage only. This generally gives a lower cost mill. Since the motor capacities of the higher speed temper mills are considerably larger than the rolling requirements, there is usually sufficient torque for roll breakaway without resorting to adjustable speed stand motors. When single stand cold mills for coils and sheets are considered, the rolling requirements generally necessitate adjustable speed motors.

Figure 13 represents power curves for rolling billets to rods. The energy ordinate of these curves excludes both motor losses and idle running friction. Deducting idle friction is an attempt to avoid multiplying mill friction by the number of strands to be rolled. The effect of sulphur in the chemical analysis is indicated by the top curve. The preparation of rolling schedules for a rod mill is more tedious than for other types of mills, and usually requires the knowledge and experience of a roll pass designer.

Figure 14 shows a power curve for the rolling of beam sizes 36 x 12 in. to 6 x 6 in. in a mill consisting of two reversing universal beam mills and a one way finishing mill. It should be noted that this curve has as its origin non-reheated beam blanks. That is, the energy required to reduce a beam blank at approximately 2000 F temperature to finished beam should only be taken from this curve. If beam blanks are reheated to a higher temperature before entry to the beam mill, the slope of the power curve will be less.

Figure 13 — Curves give power required for rolling No. 5 rod from 2½-in. square billets to 0.08 carbon mild steel on a 22-stand continuous rod mill.

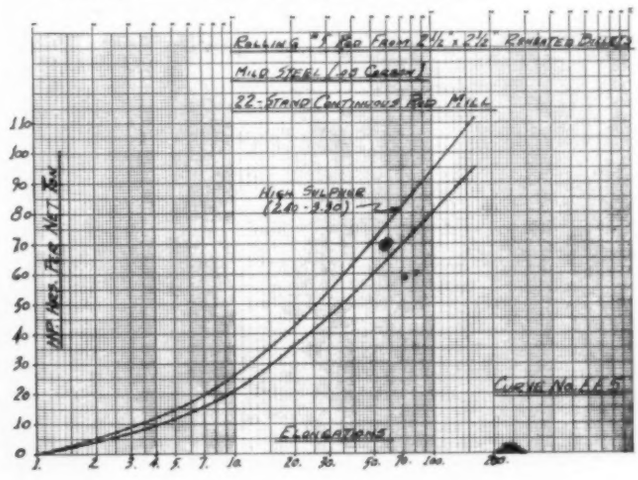
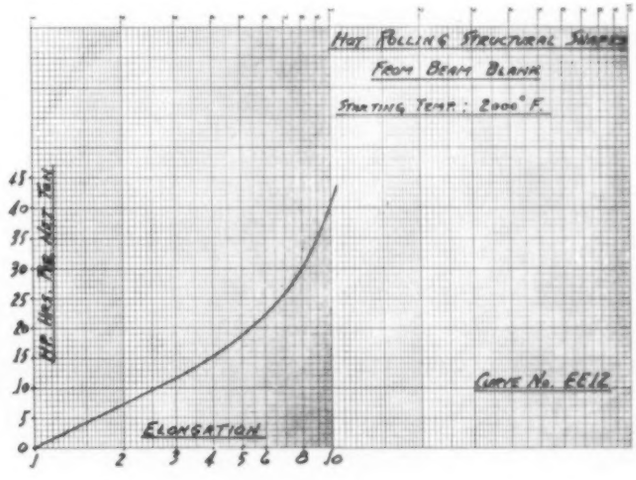


Figure 14 — Curve gives power required to hot roll structural shapes from beam blanks at starting temperature of 2000 F.



The author, in this paper, does not intend to imply that the selection of motor capacities for rolling mills is, in general, one resulting from manipulation of a "crystal ball" even though it may seem so to all of us at times. It probably suffices to state that motor selection on any drive in a metal rolling mill is based on many variables, and as we investigate these variables, the effects of some become more determinable.

DISCUSSION

PRESENTED BY

EMIL KERN, Vice President, Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

W. B. SNYDER, Senior Engineer, Propositions, Steel Mill Engineering, Systems Application Engineering Section, Apparatus Sales Division, General Electric Co., Schenectady, N. Y.

M. D. STONE, Manager, Research and Development, United Engineering & Foundry Co., Pittsburgh, Pa.

JAMES H. TAYLOR, Chief Electrical Engineer, United Engineering & Foundry Co., Pittsburgh, Pa.

Emil Kern: Information like this is always both valuable and interesting. It occured to me though, whether the data given could not be made more useful and thus further enhance the value of the paper if the actual conditions under which the power tests were made were recorded on the hphr curves.

You may have noted that on the curves shown only information on type of material and its thickness was given. I am thinking of speeds employed, the number of drafts used, steel temperature at start and finish, or total rolling time used and in the case of cold rolling, rolling oils used and tensions employed as additional information of importance.

The reason why I suggest that lies in the greater benefit our younger members might obtain from this wealth of information given by Mr. Taylor. We oldtimers usually have little trouble in guessing the type of equipment used for rolling certain metals and what the operating conditions on these mills might be.

For instance, in our line of the steel business, at Allegheny Ludlum, problems arise which make it necessary to vary at times any of the factors which enter into the rolling process in order to obtain a satisfactory product from the mill. That is why it would always be important to us to know speed, steel temperature conditions and steel analysis, certain "power curves for hot rolling" are based on.

Similarly, records of work roll size, speeds, rolling oils and tensions used for "power curves on cold rolling" would be important since they influence greatly screw pressures. I believe all this is fully realized by the author.

W. B. Snyder: We owe a vote of thanks to Mr. Taylor and his company for making available the data shown on his power curves. The information on stainless and silicon steels and on non-ferrous materials is particularly welcome, as so little data on the power requirements for rolling these products are at present available. I would like to join Mr. Taylor in a plea for more information of this type, and I can assure you that our company will be glad to do its share. We have published quite a bit of our information on rolling mill power requirements, and we stand ready to supply what additional data we have to those who need it.

Just a few words of caution regarding the use of power curves. These data are empirical, having been taken on specific mills rolling specific products under specific conditions. If one of these curves is used to calculate the requirements of a duplicate mill doing the same job, the results will be highly accurate. However if conditions vary, the results may be dangerously misleading. A change from anti-friction bearings to plain bearings may increase the power requirements as much as 50 per cent on thin material. As Mr. Taylor has mentioned, changes in roll diameters on cold mills rolling thin products affect the power requirements greatly. Temperature is also an important factor, so it is unsafe, for example, to use a curve based on rolling reheated blooms to determine the requirements of a mill rolling non-reheated blooms, or a curve based on a high speed continuous rod mill to calculate the power requirements of a Belgian mill. Alloy steels will require perhaps 25 per cent more power than mild steels, for the same rolling work. Shape rolling requires more power than flat rolling, due to the additional roll friction, and it is therefore unsafe to use a billet curve for calculating the requirements of beams or angles. The calculator should therefore have a good background of information on the source of his power data, so that he may select the power curve most nearly approximating the desired conditions, and may make allowances for factors of difference.

Mr. Taylor's curves disclose some features that seem unusual to us. The slabbing and blooming mill curve, Figure 3, starts out at a low slope which rapidly changes to a higher value and then remains essentially constant. We have observed this phenomenon in only one test, and have been inclined to discount it. Mr. Taylor advises however that his curve is a composite of several carefully made tests, all of which show this "hook." It has been our belief that power curves drawn on semi-logarithmic paper would all be essentially straight lines through the point of origin if it were not for work hardening, cooling, or compacting the material. Work hardening, of course, plays no part in hot rolling. The curve indicates negligible cooling, as the slope stays constant at the upper end. The only explanation I can see for the hook at the lower end is either that the ingot had a molten interior or a bad pipe, or perhaps that the ingot was tapered and the taper was not taken into account in recording the initial dimensions.

Another unusual feature is the manner in which the hot strip mill curves, Figures 4, 5, and 6, branch out. Figure 4, for example, shows about 38 per cent more total energy required to roll a 4-in. slab to 0.1 in. thick —when the final product is between 0.04 and 0.07 in. thick, than when the final product is 0.1 in. thick. We have never observed this in our tests, possibly because we were never fortunate enough to have such a wide variety of products to roll during our tests. However there appears to be a logical reason for this behavior.

When rolling the thinner products, greater reductions must be made per stand, resulting in higher roll pressures and greater friction losses, which could well account for the great energy consumption by the thin products. Here again it would be desirable to know if other tests have produced similar results.

Mr. Taylor described the use of power curves very throughly in his paper. We use the same method, except that we would be somewhat timid about calculating a reversing drive in the manner indicated. Our system follows that in the paper, down as far as the determination of the actual motor torques per pass, which of course determine one limiting factor in the selection of motor rating. The other factor is motor heating, and the method described gives a quick approximation of this factor which, when combined with judgment and past experience, will permit a safe motor selection in most cases. However, as the author points out, if the mill is pushed to its maximum production, and particularly if tandem rolling is to be practiced, a more detailed and more accurate calculation is indicated. Our method of doing this has been lengthy and tedious, but we have developed a system for making this calculation on a punched card machine which has taken most of the curse out of it, so we now make a complete heating calculation practically every time we calculate motor torques.

One thing to remember, in case you ask the electrical manufacturer to make motor calculations, is that while the electrical man is supposed to be an expert on everything on the motor side of the coupling, all he knows about the other side is what he reads in the paper. He is not competent to determine what the drafts per pass should be, either from metallurgical reasons or from the point of view of permissible bite angles. You should tell him whether the piece is a hot ingot, a non-reheated slab or a reheated billet, the entry dimensions of the piece, drafts for each pass, the tonnage required and, on a hot reversing mill, the manipulation to be done between passes. It is also desirable on a reversing mill to advise the entering and delivery speeds desired for each pass, as otherwise he will have to assume these figures, and you are in a better position to make these assumptions than he is. The more of this information you can obtain, the more accurate and factual the results of the calculations will be.

The selection of edger motor speeds, gear ratios and methods of supply is a broad subject, probably worthy of a separate paper. Mr. Taylor has pointed out some of the salient features affecting the selection and has indicated the desirability of a separate power supply for the edger motor, permitting draft compensation to be obtained by generator voltage variation. It might be noted that these operating advantages do not come without a price penalty. A separate edger generator will increase the number of units on the motor-generator set, and usually will increase the total capacity, as no diversity may be allowed in the selection of generator ratings. Furthermore the recommended practice of obtaining draft compensation by generator voltage changes the ratings of both the edger generator and the edger motor. It increases both the horsepower and the basic speed of the edger motor, which has only a negligible effect on price for the same torque rating, and also calls for an increased kw rating of the edger generator, which makes the supply set more expensive.

It is hoped that greater consideration will be given to the selection of edger motor speeds and gear ratio in the future. We all know of cases where edger gear ratios have been selected which force the edger motor to operate under weak field conditions when the main motor is operating at full field, thus decreasing the torque at the edger rolls and making is impossible to utilize the full capacity of the edger motor.

There are two other electrical factors in the paper upon which I would like to comment. First, on a reversing motor, the standard of 1½ sec reversal from base speed to base speed applies only to motors having a field controlled speed range of 2:1 or less, and the standard reversing time of motors having higher speed ranges is 2 sec from base speed to base speed. We agree that too much stress has lately been put on the desirability of extremely short reversing times, and would not recommend that the user incur a price penalty by specifying reversing times of less than two sec from base speed to base speed on motors having field controlled speed ranges in excess of 2:1. On the average it will take at least two sec to stop the piece on the table and return it to the mill rolls, and there is no advantage in paying extra money for a motor which will reverse more rapidly and will have to idle at entering speed waiting for the piece to re-enter.

In the discussion of hot strip mills, the statement is made that the continuous rating of 40 C rise open self-ventilated motors may be increased somewhat by forced ventilation. While this might be true in some cases it is by no means safe to assume that it is always true. The air velocities through the ventilating passages of high speed motors are about the same with self-ventilation as with forced ventilation, and therefore, usually no increase in rating can be obtained by forced ventilation.

Emil Kern: While I listened to Mr. Taylor talking about bite angles on blooming mills I was wondering if his information was precise. He told us that the bite angle for ragged rolls on blooming mills is thirty degrees and in the case of smooth rolls twenty degrees. Information I have received many years ago indicated that this condition changes with the speed of rolling.

Most blooming mill motors are rated to obtain speeds as high as 1000 fpm. I think that bite angles change in the range of 400 to 600 fpm down to about twelve degrees for smooth rolls. I believe we are all very well aware of this fact from our strip mills. The roughing mills are usually geared to 300 or 350 fpm, and only the finishing mills where the bites in actual inches are comparatively small, use higher speeds and still have the strip enter into the mill safely.

I wonder whether Mr. Stone agrees with that.

M. D. Stone: In reply to Mr. Kern's question, I do agree that at higher speeds, lower bite angles must be used. There seems to be a peculiar "critical" speed regarding the effect, around 500 fpm, as Mr. Kern pointed out.

James H. Taylor: I certainly appreciate what Mr. Kern said about requiring information on these curves.

We have that information. It is not shown in the curves, of course.

Incidentally, as mentioned in the paper, these power calculations are always steady. It has some bearing on the power calculations, so if one is not clear as to where the power curve has been obtained, in the long run it does not make a lot of difference. The values of bite angles that I gave are approximations and you can take them for what they are worth. If in figuring power calculations, you change bite angles to correspond with speed, it would take quite a while to do all that.

With reference to Mr. Snyder's comment on my paper, I certainly agree with his statements in general. On the subject of slab and bloom mill power curves, my opinion is that the reason for the lower slope of the curve near its point of origin is due to the fact that an ingot coming from the soaking pits is not compact within its structure and, therefore, in closing the voids within the ingot in the first few passes, less torque would be required for the same amount of material reduction as taken in the later passes. I am inclined to agree with Mr. Snyder that it would seem logical for the curve to increase its slope near its end due to cooling of the ingot, however, we have actually found little change in the power requirements as the ingot exterior cools from 2300 to about 2100 F finishing as a slab. Perhaps this can be explained by the fact that the interior of the *large* ingot does not lose its temperature during rolling as much as the exterior, and although there is interior cooling, it is not enough to indicate a difference in power to the ordinary power measuring instruments under the usual conditions of obtaining power data on a slabbing mill.

Referring to the subject of slabbing mill edger motor speed and gear ratios and Mr. Snyder's statement that draft compensation by generator voltage changes the ratings of both the edger generator and edger motor, I would agree that this is possible. However, on the type slab mills discussed in my paper, applying separate generators for draft and roll diameter compensation, does not, I believe, increase the rating of the edger generator, but does with the proper gear ratio, reduce the edger motor field range required for speed synchronism with the horizontal mill.

Relative to hot strip mill motors, I take note of Mr. Snyder's statement that there is usually no increase in continuous rating by force ventilating a motor which is rated on a self-ventilated basis. Since Mr. Snyder represents a motor manufacturer and I do not, it would not be my intention to disagree with him. However, it would appear to me offhand that even if the air velocities are the same through the motor ventilating passages, the air would be initially of lower temperature in the average mill ventilation system than under temperature conditions in which the motor is giving a self-ventilated rating, and consequently the continuous motor capacity would be increased somewhat.

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EFFECT OF FINISHING TEMPERATURES on properties of hot rolled steel plate

By R. H. FRAZIER
Assistant Chief
F. W. BOULGER
Chief
Division of Ferrous Metallurgy
and
C. H. LORIG
Technical Director
Physical and Process Metallurgy
Battelle Memorial Institute
Columbus, Ohio

▲ IN 1954, over five million tons of steel plate were hot-rolled in the United States. Most of it was used in the as-rolled condition because furnace facilities for heat treating this plate are limited. Therefore, the properties of the plate as it leaves the mill will determine its performance in the tank, ship, bridge, pipeline, or other construction in which it is used. Variations in mill practice are known to influence the properties of plate. The purpose of this paper is to show the influence of one variable, finishing temperature, on the properties of the plate in the hot-rolled condition. The temperature of the plate during the last pass on the rolling mill is important even though it is not the only factor influencing mechanical properties.

This study on the effect of finishing temperature, and incidentally on the influence of aluminum additions, was made on semikilled and killed steels. Rimmed steels were not investigated although appreciable tonnages are rolled into plate.

This investigation was part of a research project dealing with the quality characteristics of ship plate material sponsored at Battelle by the Bureau of Ships, Department of the Navy*.

LABORATORY SEMIKILLED STEELS

For a preliminary study, two semikilled steels were prepared from 200 lb induction-furnace melts. The charge was melted under an atmosphere of argon to insure a low nitrogen content of the same order found in commercial open-hearth steel. After making the necessary additions to obtain the desired chemical composition, the entire heat was poured directly into a 6 x 6-in. big-end-up mold and the ingot capped with a steel plate. The ingots were processed by heating to 2250 F, followed by forging to slabs $1\frac{3}{4}$ in. thick by 6 in. wide. After reheating to 2250 F, the slabs were rolled to $\frac{7}{8}$-in. gage, using reductions of approximately $\frac{1}{16}$ in. per pass. One-third of each ingot was recharged in a furnace held at 1650 F, another section of each ingot recharged in a furnace held at 1750 F, and the remaining third of each ingot placed in a furnace held at 1850 F. After 20 minutes or more in the furnace, the plates were reduced to $\frac{3}{4}$ in. in one pass. Following this final pass, the plates were placed on edge on a brick floor, with a brick separating each plate, and allowed to cool in still air.

The chemical compositions and tensile properties of plates rolled from the laboratory heats are listed in Table I. All values are averages for duplicate determinations.

The data show that the yeild strength increased significantly as the finishing temperature was decreased from 1850 to 1650 F. The ultimate strength of the steels was not affected by the temperature during the last pass on the rolling mill. Consequently, the ratio of the yield strength to the ultimate strength increased slightly with decreases in rolling temperature. Although the elongation values varied from plate to plate they did not change consistently with finishing

*The opinions expressed herein are those of the authors. They do not necessarily represent those of the Ship Structure Committee, the Bureau of Ships, the Department of the Navy, nor the Advisory Committees of the National Academy of Sciences, National Research Council.

TABLE I

Chemical Analysis and Tensile Properties of Two Semikilled Steels Finished at Different Temperatures

Heat No.	Composition, per cent					
	C	Mn	P	S	Si	N
A6424	0.21	0.42	0.014	0.029	0.02	0.004
A6365	0.14	0.95	0.021	0.028	0.06	0.004

Heat No.	Finishing temp, F	Yield strength, psi	Tensile strength, psi	Yield strength/ tensile strength ratio	Elongation in 8 in., per cent	Tear-test (1) transition temp, F	Charpy impact (2) transition temp, F
A6424	1650	37,950	57,200	66.3	31.5	+50	+ 6
A6424	1750	34,650	57,600	60.1	31.0	+60	+26
A6424	1850	34,000	58,250	58.4	29.0	+90	+40
A6365	1650	40,150	64,000	62.8	29.0	+10	−54
A6365	1750	38,650	63,700	60.7	32.0	+20	−38
A6365	1850	38,150	63,850	59.8	31.5	+40	−30

(1) The highest temperature at which one or more specimens exhibited a fracture area of less than 50 per cent of the ductile shear type.

(2) Temperature at which the Charpy impact value is 12 foot-pounds.

TABLE II

Chemical Composition of Experimental Open-Hearth Steels

Steel Co.	Steel	Composition, per cent							Aluminum added, lb per ton of steel
		C	Mn	P	S	Si	Aluminum		
							Acid sol.	Acid insol.	
Type A Steel — 0.25 per cent C, 0.45 per cent Mn									
W	W-1	0.23	0.52	0.013	0.037	0.09	<0.003	<0.003	0
W	W-2	0.23	0.52	0.011	0.037	0.10	<0.003	<0.003	1/4
W	W-3	0.23	0.52	0.012	0.041	0.09	<0.003	<0.003	1/2
W	W-4	0.23	0.52	0.013	0.039	0.10	0.020	<0.003	1
Z	Z-5	0.27	0.50	0.017	0.041	0.06	<0.003	<0.003	3/16
Z	Z-6	0.27	0.51	0.017	0.042	0.06	<0.003	<0.003	3/8
Z	Z-7	0.27	0.49	0.017	0.042	0.06	0.006	<0.003	3/4
Z	Z-8	0.27	0.50	0.018	0.042	0.06	0.043	<0.003	1 1/2
V	V-1	0.26	0.45	0.008	0.032	0.09	<0.003	<0.003	0 (1)
V	V-2	0.27	0.45	0.009	0.032	0.07	<0.003	<0.003	0.09
V	V-3	0.28	0.46	0.009	0.032	0.09	0.005	0.011	0.54
V	V-4	0.29	0.45	0.009	0.032	0.07	0.018	0.009	0.84
Type B Steel — 0.21 per cent C, 0.75 per cent Mn									
W	W-5	0.23	0.78	0.012	0.025	0.09	<0.003	<0.003	0
W	W-6	0.22	0.80	0.013	0.026	0.08	<0.003	0.006	1/4
W	W-7	0.20	0.80	0.012	0.025	0.08	<0.003	0.008	1/2
W	W-8	0.21	0.78	0.013	0.026	0.08	0.029	0.008	1
Z	Z-1	0.19	0.67	0.012	0.028	0.04	<0.003	<0.003	3/16
Z	Z-2	0.19	0.68	0.013	0.028	0.04	<0.003	0.003	3/8
Z	Z-3	0.18	0.68	0.012	0.027	0.04	0.003	<0.003	3/4
Z	Z-4	0.19	0.68	0.013	0.027	0.04	0.027	<0.003	1 1/2
V	V-5	0.21	0.67	0.012	0.033	0.07	<0.003	0.005	0 (1)
V	V-6	0.19	0.67	0.011	0.032	0.07	0.004	0.006	0.09
V	V-7	0.22	0.67	0.012	0.033	0.07	0.006	0.012	0.54
V	V-8	0.19	0.66	0.011	0.033	0.08	0.017	0.008	0.84

(1) An addition of 0.4 pound of 84 per cent ferrosilicon was made to the top of the ingot.

temperatures. These conclusions were supported by data obtained on other semikilled steels made in the laboratory.

The tendency for steel plates to fail in a brittle manner is particularly important in many applications. This characteristic of metals is usually evaluated by testing notched-bar specimens over a range in temperatures. Briefly, the evaluation is based on the temperature at which the energy required for rupture decreases suddenly. This transition from the ductile to the brittle mode is termed the transition temperature. Data for comparatively few specimens listed in Table

TABLE III

Open-Hearth and Rolling Data for Three Experimental Type A Steels (0.25 per cent C, 0.45 per cent Mn)

Steel company	W	V	Z
Heat	64C623	8504	65M439
Furnace additions	Not reported	None	None
Ladle additions:			
80 Per cent FeMn	2.25 lb per ton	10.9 lb per net ton	12.82 lb per ton
50 Per cent FeSi	4.5 lb per ton	3.4 lb per net ton	2.99 lb per ton
Coke	None	1.4 lb per net ton	None
Coal	None	None	0.85 lb per ton
Mold additions:			
84 Per cent FeSi	None	0.4 lb (1)	None
Aluminum	0 to 1 lb per ton	0 to 0.84 lb per ton	3/16 to 1 1/2 lb per ton
Mold size:			
Plain top	26 x 50 x 84 in.	—	Not reported
Hot top	31 x 50 x 66 in.	—	Not reported
For 3/4-in. plate	—	22 1/2 x 34 in.	Not reported
For 1 3/4-in. plate	—	22 1/2 x 24 1/2 in.	Not reported
Cross rolling	Not reported	None	Some (2)
Finishing temp for 3/4-in. plates	1700-1750 F	1850-1990 F	1850-1890 F

Footnotes:

(1) An addition of 0.4 pound of 84 per cent ferrosilicon was made to the top of the ingot containing no aluminum.

(2) The ingots were rolled straightaway to slabs 60 in. wide by 8 in. thick. To produce the 3/4-in. plates, the slabs were cross rolled 112 per cent to a width of 127 in. before final rolling. To produce the 1 3/4-in. plates, the slabs were cross rolled 28.4 per cent to a width of 77 in.

TABLE IV

Open-Hearth and Rolling Data for Three Experimental Type B Steels (0.21 per cent C, 0.75 per cent Mn)

Steel company	W	V	Z
Heat	67C658	6354	73M393
Furnace additions:			
80 Per cent FeMn	Not reported	None	16.5 lb per ton
20 Per cent spiegeleisen	Not reported	6.3 lb per net ton	None
15 Per cent FeSi	Not reported	None	12.8 lb per ton
Ladle additions:			
80 Per cent FeMn	9.1 lb per ton	16.9 lb per net ton	6.16 lb per ton
50 Per cent FeSi	4.0 lb per ton	3.0 lb per net ton	0.62 lb per ton
Coke	None	0.4 lb per net ton	None
Mold additions:			
84 Per cent FeSi	None	0.5 lb (1)	None
Aluminum	0 to 1 lb per ton	0 to 0.84 lb per ton	3/16 to 1 1/2 lb per ton
Mold size:			
Plain top	26 x 50 x 80 in.	—	—
Hot top	31 x 50 x 65 in.	—	—
For 3/4-in. plate	—	22 1/2 x 34 in.	—
For 1 3/4-in. plate	—	22 1/2 x 24 1/2 in.	—
Cross rolling	Not reported	None	Some (2)
Finishing temp for 3/4-in. plates	1700-1800 F	1980-2000 F	1810-1830 F

Footnotes:

(1) An addition of 0.5 pound of 84 per cent ferrosilicon was made to the top of the ingot containing no aluminum.

(2) The ingots were rolled straightaway to slabs 60 in. wide by 8 in. thick. To produce the 3/4-in. plate, the slabs were cross rolled 112 per cent to a width of 127 in. before final rolling. To produce the 1 3/4-in. plates, the slabs were cross rolled 28.4 per cent to a width of 77 in.

I show that lower transition temperatures were characteristic of plates rolled at lower temperatures. This point seemed worthy of further study.

EXPERIMENTAL OPEN-HEARTH STEELS

Reliable estimates of transition temperatures require testing approximately 20 notched-bar specimens over the temperature range of interest. Tear-test specimens are 3 x 5 in. x plate thickness. Because of the amount of stock required for such tests, experimental open-hearth steels were procured for studying the effect of finishing temperature on notched-bar properties. Three of the major producers of steel plates cooperated by furnishing materials for the investigation.

Two types of steel, one containing approximately 0.25 per cent carbon and 0.45 per cent manganese (Type A), the other containing 0.21 per cent carbon and 0.75 per cent manganese (Type B), were studied. The silicon contents of all steels were within the normal range for semikilled steels. Each company furnishing the steels added various amounts of aluminum to the molds to produce four ingots of each steel grade with different aluminum contents. The acid-soluble-aluminum content of the steels containing the largest aluminum addition was intended to be approximately 0.020 per cent. Normally, an addition to give this amount of aluminum would be made to the ladle instead of to the ingot in the mold. Because of this variation from normal practice, all of the steels should be classed as being of experimental rather than of commercial quality.

The chemical analyses of the various plates furnished by the steel companies are shown in Table II. The carbon contents varied from 0.23 per cent to 0.29 per cent in Type A steels and from 0.18 per cent to 0.23 per cent in Type B steels. Manganese ranged from 0.45 per cent to 0.52 per cent in Type A steels and from 0.66 per cent to 0.80 per cent in Type B steels. All of the steels had low phosphorus contents, the highest reported value being 0.017 per cent. Sulphur contents were within narrow limits and averaged 0.032 per cent. The silicon contents were under 0.11 per cent.

Each steel company had certain practices of steelmaking and rolling which were followed in producing the experimental plates. The melting and rolling data for each heat are summarized in Tables III and IV. The reported furnace and ladle additions were made to give the desired steel compositions. Company "V" also made an addition of ferrosilicon to the top of the ingot containing no aluminum to control mold action. Company "Z" found it necessary to add three ounces of aluminum per ton of steel to control the mold action in the ingots intended to be free of aluminum.

The plates were rolled from various sized ingots, as indicated in the tables. During their rolling, therefore, the plates received different rolling reductions which might have some influence on their properties. Company "Z" reported that some cross rolling was done on their plates. The average finishing temperature of plates from Company "W" was reported to be almost 300 F lower than the average for plates from Company "V."

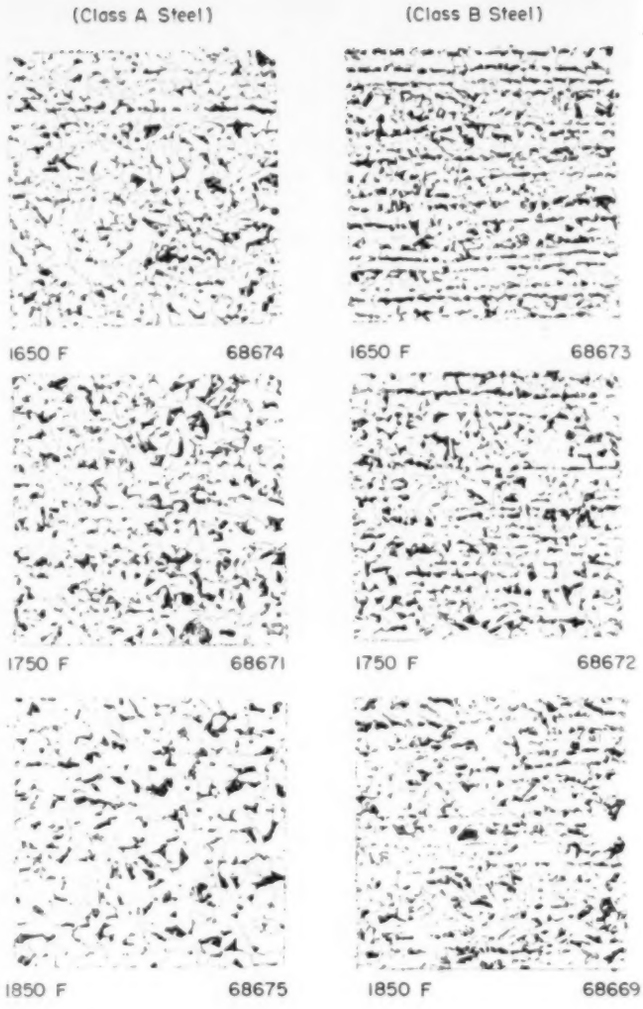

Figure — 1 Microstructure of steels finished at 1650, 1750, and 1850 F shows that the ferrite grains become larger as the finishing temperature is raised.

Each of the three steel companies furnished eight ¾-in. and eight 1¾-in. thick plates for the investigation. One plate of each thickness was taken from each ingot made for the program. The ¾-in. plates produced by the steel plants were tested in the as-received condition. The 1¾-in. plates were rolled to ¾-in. plates at Battelle using a laboratory rolling mill and finishing at either 1650, 1850, or 2050 F. These sections of the 1¾-in. plate were first heated to 2250 F and rolled without reheating to 0.9 in. using reductions of ⅙ in. per pass. After the initial rolling, the plates were placed in a furnace at the desired finishing temperature, held for thirty minutes, and then rolled to ¾-in. plate in a single pass. The plates were placed on edge, separated from each other by a brick, and allowed to cool in air. Test specimens were then cut from these plates.

INFLUENCE OF FINISHING TEMPERATURE ON FERRITE GRAIN SIZE

It is well known that the ferrite grain size of a steel will influence its mechanical properties[3]. Therefore, each steel plate was examined metallographically for differences in the sizes of the ferrite grains. Photomicrographs of the two laboratory steels finished at the

three temperatures are shown in Figure 1. It will be noted that as the finishing temperature is raised the ferrite grains become larger.

For the open-hearth steels, the ferrite grain size of each plate was determined by a counting method which had been described in an earlier publication[2]. Photomicrographs taken on both longitudinal and transverse cross sections of the plates were used to obtain the average grain count given in Table V. Variations in aluminum content did not significantly affect the ferrite grain size of the hot-rolled plates from a given series finished rolled at the same temperature. This observation was also noted in a study[1] using laboratory induction-melted steels. Finishing temperature, on the other hand, did influence the ferrite grain size of plates rerolled in the laboratory, as shown in Figure 2. A decrease of 400 F in finishing temperature reduced the ferrite grain size, on the average, almost one ASTM (American Society for Testing Materials) grain-size number. Hodge and others[3] found that a reduction in ferrite grain size corresponding to one ASTM number lowers the Charpy transition 30 F. Accordingly, lowering the finishing temperature from 2050 F to 1650 F, as was done in the present study, would be expected to lower the Charpy transition temperature almost 30 F. As discussed later, the actual change in transition temperature was 25 F over this range in finishing temperature.

KEYHOLE-NOTCH CHARPY PROPERTIES

The familiar Charpy test was one that was used to determine the susceptibility of the steel to brittle failure. At low temperatures, ferritic steels fail with a shiny, brittle fracture. As the temperature is increased, this indication of brittleness disappears and the fracture exhibits a dull, ductile appearance. The energy required to fracture the specimen increases as the fracture appearance changes from a brittle one to a ductile one. It has been shown that the temperature at which this transition takes place correlates with the actual service performance of ship plate[8]. A low transition temperature means the steel is less likely to fail in a brittle fashion.

The Charpy transition curve for each steel was determined from the average values of four specimens broken at each of several temperatures 10 F apart. The specimens were taken from the center of the plate thickness parallel to the direction of rolling and were notched normal to the plate surface. A bath of ethyl alcohol cooled by dry ice was used to obtain the desired temperature for specimens tested below room temperature. The specimens tested at room temperature or above were heated in a water bath.

The transition temperature used for interpreting the results was defined as the temperature at which the average Charpy value was 12 ft-lb.

TABLE V

Ferrite Grain Size of ¾-in. Experimental Open-Hearth Steel Plates

Steel	Composition, per cent①			Aluminum added, lb per ton of steel	Commercially finished plate		No. of ferrite grains per square in. at 100X③ of laboratory-finished plate		
	C	Mn	Al②		Finishing temp, F	No. of ferrite grains per square in. at 100X③	Finished at 1650 F	Finished at 1850 F	Finished at 2050 F
W-1	0.23	0.52	<0.003	0	1700	116	79	72	66
W-2	0.23	0.52	<0.003	0.25	1750	87	86	81	65
W-3	0.23	0.52	<0.003	0.50	1750	85	83	77	63
W-4	0.23	0.52	0.020	1.00	1700	81	103	67	63
W-5	0.23	0.78	<0.003	0	1700	66	107	86	69
W-6	0.22	0.80	<0.003	0.25	1725	94	103	88	68
W-7	0.20	0.80	<0.003	0.50	1800	79	95	75	68
W-8	0.21	0.78	0.029	1.00	1725	107	101	79	71
Z-5	0.27	0.50	<0.003	0.19	1890	67	121	112	68
Z-6	0.27	0.51	<0.003	0.38	1850	80	88	88	83
Z-7	0.27	0.49	0.006	0.75	1855	83	97	83	45
Z-8	0.27	0.50	0.043	1.50	1890	73	96	77	57
Z-1	0.19	0.67	<0.003	0.19	1820	67	91	75	63
Z-2	0.19	0.68	<0.003	0.38	1810	58	81	69	55
Z-3	0.18	0.68	0.003	0.75	1830	58	98	68	47
Z-4	0.19	0.68	0.027	1.50	1830	65	114	67	59
V-1	0.26	0.45	<0.003	0	1950	72	69	88	71
V-2	0.27	0.45	<0.003	0.09	1965	72	115	86	77
V-3	0.28	0.46	0.005	0.54	1850	80	78	78	74
V-4	0.29	0.45	0.018	0.84	1990	68	88	82	71
V-5	0.21	0.67	<0.003	0	2000	64	97	88	61
V-6	0.19	0.67	0.004	0.09	1980	79	98	79	55
V-7	0.22	0.67	0.006	0.54	2000	65	83	65	66
V-8	0.19	0.66	0.017	0.84	1990	58	97	73	64

① Composition of the commercially finished ¾-in. plate.

② Acid-soluble-aluminum content.

③ Ferrite grain count is the average of two determinations.

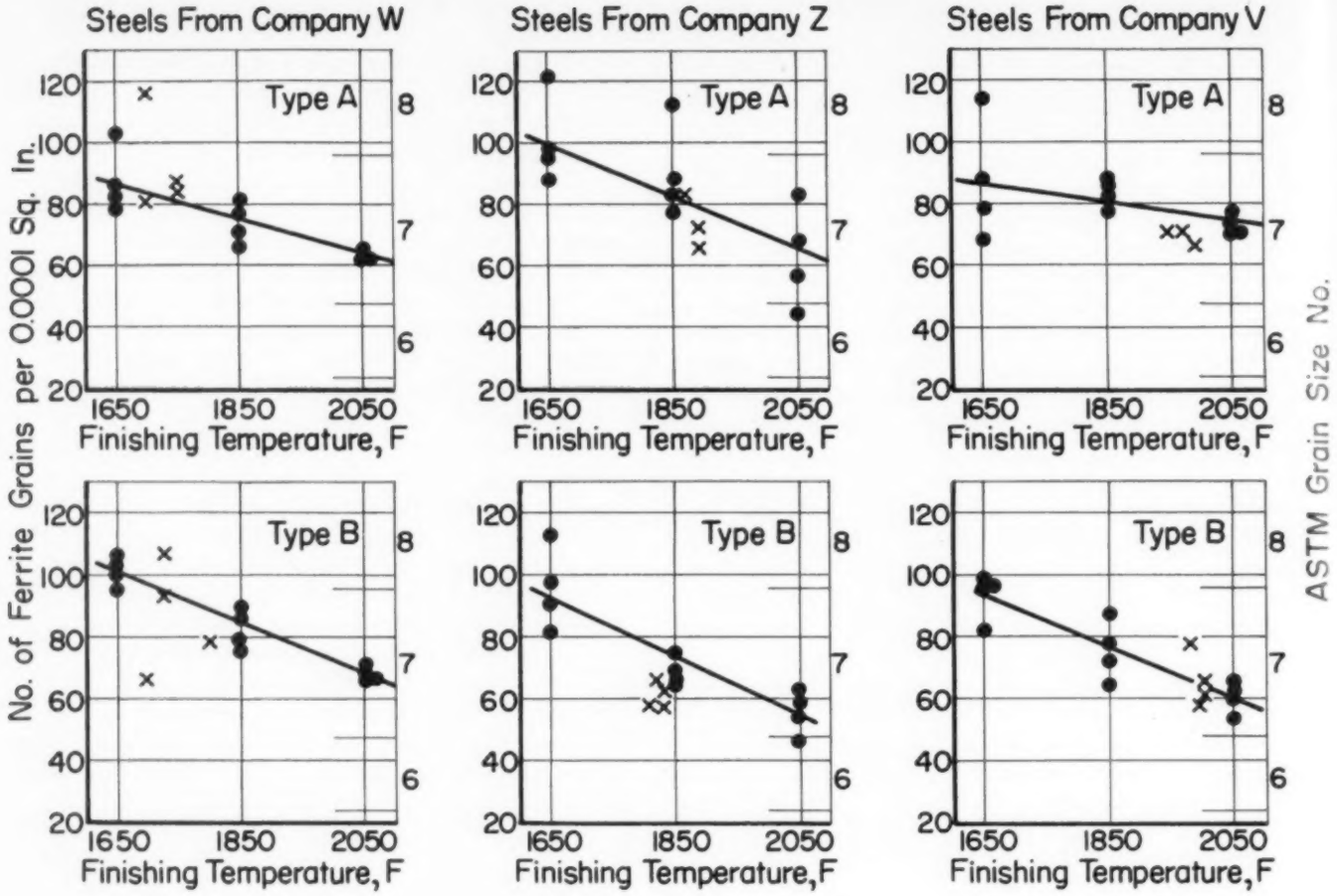

Figure 2—A decrease of about 400 F in finishing temperature will reduce the ferrite grain size one ASTM grain size number.

The transition temperatures for each open-hearth steel rolled at each of four finishing temperatures are shown in Table VI.

The Charpy transition temperatures of the steel plates rolled from 1¾ to ¾ in. in the laboratory mill generally increased with increases in finishing temperature. In Figure 3, the average Charpy transition temperatures are plotted against finishing temperatures. The transition temperatures of plates finish rolled in the commercial mills are also shown. On the average, an increase of 100 F in finishing temperature was found to raise the transition temperature 6 F. The data for plates from the same heats that had been rerolled in the laboratory fit straight lines very well. The variation in slopes of the lines, however, cannot be explained on the basis of the information available. The transition temperatures of the plates finished in commercial mills were always higher than those of plates which had been finish rolled in the laboratory. In some cases, this difference in transition temperature was as much as 20 F for plate finish rolled at the same temperature. One possible explanation for this difference might be that the plate finished in commercial mills cooled more slowly after rolling than did the plate rerolled in the laboratory. Slower cooling of the plate would result in a higher transition temperature[7].

TEAR TEST PROPERTIES

The Navy tear test developed by Kahn and Imbembo[5] used a specimen of the type shown in Figure 4. The specimen is loaded in tension, with pin-and-shackle fixtures through the large holes, while submerged in a liquid bath for temperature control. This test is sensitive to temperature changes in a manner similar to that of the Charpy test; that is, fractures at low temperatures are of the brittle type.

Four tear-test specimens of each steel were broken at each 10 F interval in the transition range. These tests gave sufficient information to determine the tear-test transition temperature by any one of three criteria. One criterion of the test, originated by Kahn and Imbembo[5], is the highest temperature at which one or more of four specimens will break with a fractured area having less than 50 per cent of the dull, fibrous type of fracture. This transition temperature can be determined from as few as five specimens and depends to a large extent on the performance of one specimen. The other two criteria, which are more reliable in research work, base the transition temperature on the performance of all specimens tested. In one case, the transition temperature is that temperature where the probability of brittle fracture, p, equals 0.5.

TABLE VI

Summary of Chemical Compositions and Keyhole Charpy Transition Temperatures③ of Experimental Open-Hearth Steels

Steel	Composition, per cent①			Commercially finished plate		Keyhole Charpy transition temperatures of laboratory-finished plate, F		
	C	Mn	Al②	Finishing temp, F	Keyhole Charpy transition temp, F	Finished at 1650 F	Finished at 1850 F	Finished at 2050 F
W-1	0.23	0.52	<0.003	1700	—19	—34	—10	—18
W-2	0.23	0.52	<0.003	1750	—17	—17	—10	—14
W-3	0.23	0.52	<0.003	1750	+ 2	—33	—38	—25
W-4	0.23	0.52	0.020	1700	—15	—34	—31	—22
W-5	0.23	0.78	<0.003	1700	— 8	—50	—23	—13
W-6	0.22	0.80	<0.003	1725	— 4	—43	—17	— 5
W-7	0.20	0.80	<0.003	1800	—43	—63	—49	—37
W-8	0.21	0.78	0.029	1725	—37	—62	—40	—40
Z-5	0.27	0.50	<0.003	1890	— 1	—14	—10	+ 8
Z-6	0.27	0.51	<0.003	1850	+ 2	—16	— 7	+ 9
Z-7	0.27	0.49	0.006	1855	+ 9	— 2	+12	+21
Z-8	0.27	0.50	0.043	1890	0	—14	—10	+18
Z-1	0.19	0.67	<0.003	1820	—18	—37	—30	—12
Z-2	0.19	0.68	<0.003	1810	—10	—31	—16	— 4
Z-3	0.18	0.68	0.003	1830	—16	—38	—21	— 4
Z-4	0.18	0.68	0.027	1830	—37	—53	—35	—17
V-1	0.26	0.45	<0.003	1950	+22	—14	+ 2	— 3
V-2	0.27	0.45	<0.003	1965	+28	— 1	+ 9	+ 8
V-3	0.28	0.46	0.005	1850	+11	—16	— 5	+ 8
V-4	0.29	0.45	0.018	1990	+27	—20	— 5	— 1
V-5	0.21	0.67	<0.003	2000	— 4	—23	—10	—23
V-6	0.19	0.67	0.004	1980	0	—30	—27	—18
V-7	0.22	0.67	0.006	2000	—21	—50	—41	—22
V-8	0.19	0.66	0.017	1990	—16	—64	—34	—31

① Composition of the commercially finished ¾-in. plate.
② Acid-soluble-aluminum content.
③ The transition temperature is defined as the temperature at which the average Charpy value is 12 foot-pounds.

In the other case, the transition temperature is that temperature where the fracture shows 50 per cent or more of brittle texture. Transition temperatures, based on either of the two latter criteria, are in close agreement[6]. The criterion used by Kahn and Imbembo and the criterion based on the probability of brittle fracture, p=0.5, were the only ones employed in this investigation to obtain the transition temp-

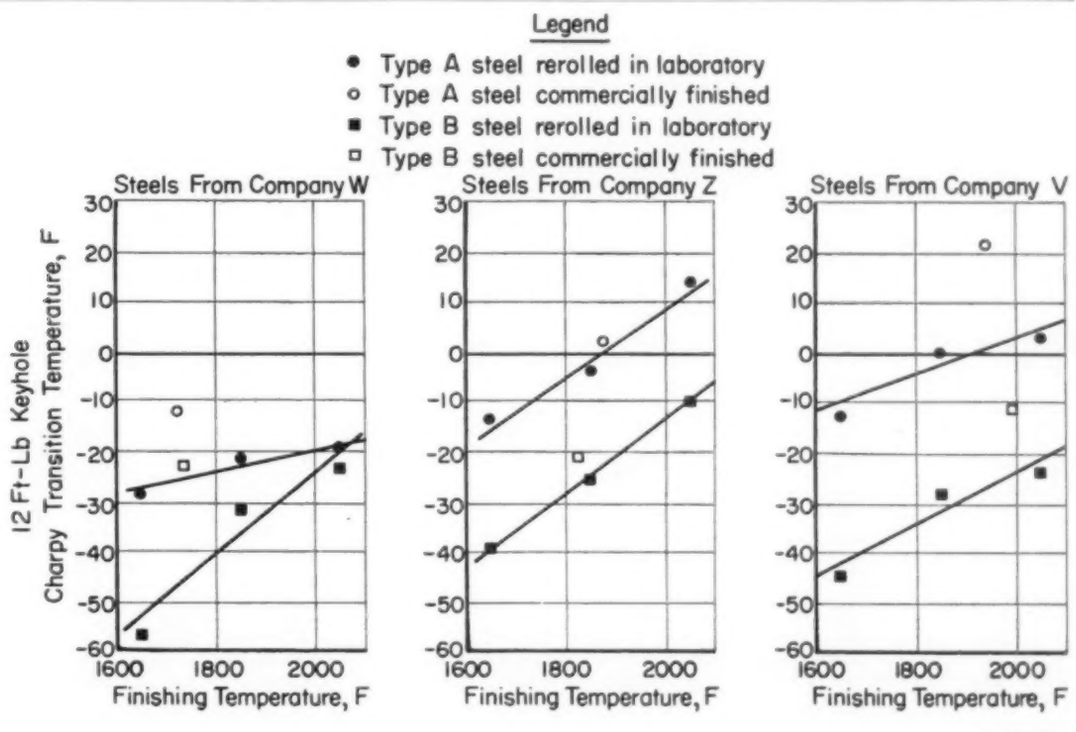

Figure 3 — With lower finishing temperatures, the Charpy transition temperature is lowered.

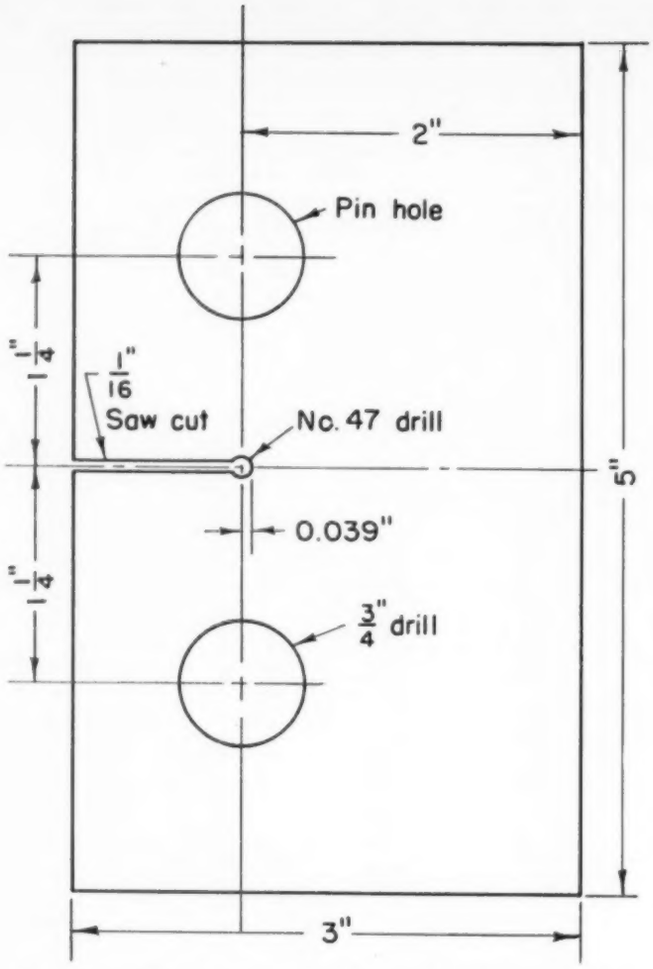

Figure 4 — The Navy tear test is sensitive to temperature changes.

eratures from the tear-test data.

The transition temperatures of the open-hearth steels used in this investigation, based on the Kahn and Imbembo criterion, are given in Table VII, whereas the transition temperatures based on the criterion defined as the probability of brittle fracture, p=0.5, are given in Table VIII.

As was the case with the transition temperatures in the Charpy test, the transition temperatures in the tear test were affected only slightly by variations in the acid-soluble-aluminum contents of the plates up to 0.043 per cent. The indications are that increasing the aluminum content above 0.01 per cent decreased the tear-test transition temperature slightly.

The effect of finishing temperature on the tear-test transition temperature based on the p=0.5 probability of brittle fracture is shown clearly by the curves in Figure 5. A decrease in finishing temperature lowered the transition temperature appreciably, the actual change being an average reduction in the transition temperature of 8 F on decreasing the finishing temperature 100 F. This reduction is slightly more than the 6 F shown in an earlier section of this report for the change in Charpy transition temperature with a reduction of 100 F in finishing temperature.

For the same finishing temperature, plates finish rolled on commercial mills had tear-test transition temperatures that were higher than those for plates finished rolled in the laboratory. Again the explanation may be that the plates finished on commercial mills were cooled from the rolling temperature at a slower rate than plates rolled in the laboratory. As mentioned before, slow cooling has been shown[7] to raise the transition temperature.

AUSTENITE GRAIN-COARSENING TEMPERATURE

The austenite grain-coarsening temperature was determined for each of the 32 experimental steels after heating test specimens, 3/8 x 1/2 x 5 in. in size, in a temperature-gradient furnace for periods of one hour and four hours. The furnace used for the work resembled

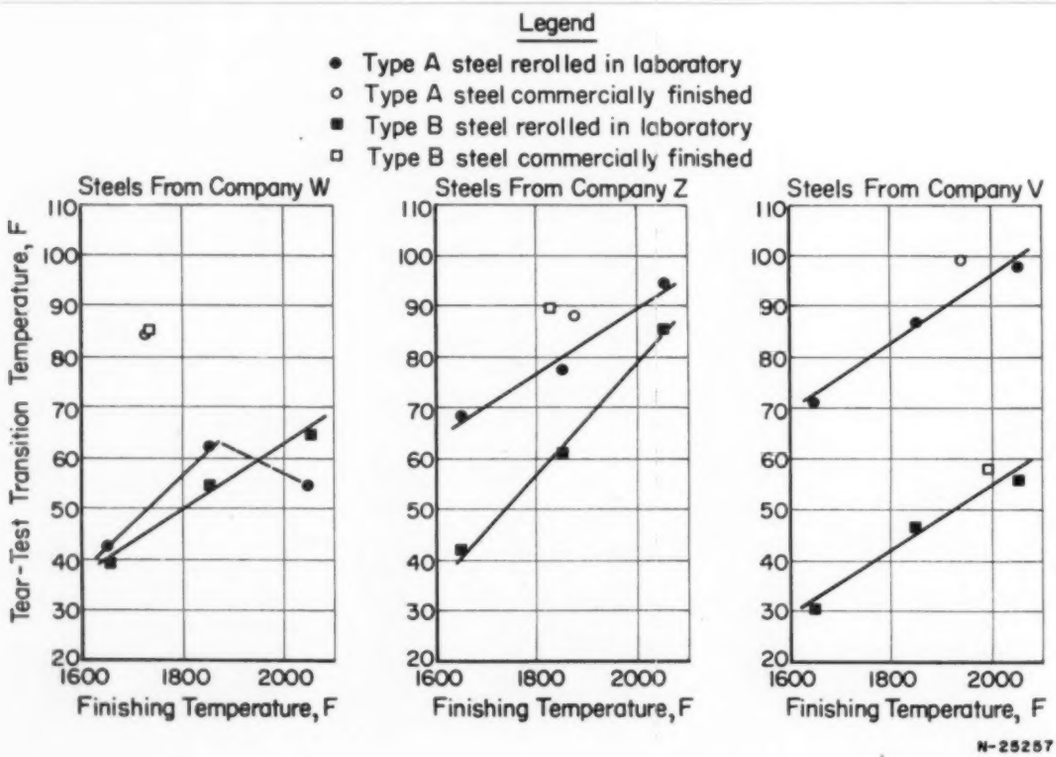

Figure 5 — The tear test also shows that a decrease in finishing temperature lowers the transition temperature appreciably.

the one described by Halley[4]. It had a temperature gradient of 400 F from one end of the specimen to the other. The specimens were quenched in oil immediately after being taken from the furnace, after which they were sectioned and etched. From an examination of the etched surfaces and the known temperature gra-

TABLE VII

Tear-Test Transition Temperatures of the Experimental Open-Hearth Steels Based on Kahn and Imbembo Criterion

Steel	Composition, per cent			Commercially rolled plate		Transition temperature of laboratory rerolled plate, F		
	C	Mn	Al	Finishing temp, F	Transition temp, F	Finished at 1650 F	Finished at 1850 F	Finished at 2050 F
W-1	0.23	0.52	<0.003	1700	80	50	80	60
W-2	0.23	0.52	<0.003	1750	90	40	60	70
W-3	0.23	0.52	<0.003	1750	100	70	80	60
W-4	0.23	0.52	0.020	1700	80	70	70	70
W-5	0.23	0.78	<0.003	1700	110	30	60	100
W-6	0.22	0.80	<0.003	1725	110	40	60	70
W-7	0.20	0.80	<0.003	1800	80	60	60	70
W-8	0.21	0.78	0.029	1725	80	30	40	70
Z-5	0.27	0.50	<0.003	1890	90	90	90	110
Z-6	0.27	0.51	<0.003	1850	110	90	90	90
Z-7	0.27	0.49	0.006	1855	90	60	80	100
Z-8	0.27	0.50	0.043	1890	80	60	80	80
Z-1	0.19	0.67	<0.003	1820	60	50	60	100
Z-2	0.19	0.68	<0.003	1810	60	60	80	100
Z-3	0.18	0.68	0.003	1830	70	50	70	90
Z-4	0.19	0.68	0.027	1830	50	30	60	90
V-1	0.26	0.45	<0.003	1950	90	70	100	110
V-2	0.27	0.45	<0.003	1965	120	90	90	90
V-3	0.28	0.46	0.005	1850	100	80	80	100
V-4	0.29	0.45	0.018	1990	120	60	100	110
V-5	0.21	0.67	<0.003	2000	70	50	50	90
V-6	0.19	0.67	0.004	1980	60	30	40	60
V-7	0.22	0.67	0.006	2000	70	40	70	60
V-8	0.19	0.66	0.017	1990	60	30	80	50

TABLE VIII

Tear-Test Transition Temperatures of the Experimental Open-Hearth Steels Based on the Criterion of the Probability of Brittle Fracture, p, Equal to 0.5

Steel	Composition, per cent			Commercially rolled plate		Transition temperature of laboratory rolled plate, F		
	C	Mn	Al	Finishing temp, F	Transition temp, F	Finished at 1650 F	Finished at 1850 F	Finished at 2050 F
W-1	0.23	0.52	<0.003	1700	81	40	64	40
W-2	0.23	0.52	<0.003	1750	87	40	55	65
W-3	0.23	0.52	<0.003	1750	98	49	63	55
W-4	0.23	0.52	0.020	1700	70	59	66	58
W-5	0.23	0.78	<0.003	1700	108	35	56	75
W-6	0.22	0.80	<0.003	1725	105	45	65	66
W-7	0.20	0.80	<0.003	1800	71	53	57	64
W-8	0.21	0.78	0.029	1725	57	23	40	53
Z-5	0.27	0.50	<0.003	1890	90	76	85	107
Z-6	0.27	0.51	<0.003	1850	100	83	90	90
Z-7	0.27	0.49	0.006	1855	90	62	71	99
Z-8	0.27	0.50	0.043	1890	75	54	64	81
Z-1	0.19	0.67	<0.003	1820	65	45	61	92
Z-2	0.19	0.68	<0.003	1810	57	62	75	89
Z-3	0.18	0.68	0.003	1830	55	42	59	80
Z-4	0.19	0.68	0.027	1830	38	19	50	83
V-1	0.26	0.45	<0.003	1950	90	68	90	103
V-2	0.27	0.45	<0.003	1965	105	80	90	95
V-3	0.28	0.46	0.005	1850	93	73	85	95
V-4	0.29	0.45	0.018	1990	110	65	85	100
V-5	0.21	0.67	<0.003	2000	55	36	35	59
V-6	0.19	0.67	0.004	1980	50	29	41	55
V-7	0.22	0.67	0.006	2000	67	30	52	64
V-8	0.19	0.67	0.017	1990	61	26	58	47

TABLE IX

Austenite Grain-Coarsening Temperatures of Twenty-Four Open-Hearth Steels of Various Aluminum Contents
(Specimens Heated One and Four Hours)

Steel	Composition, per cent				Aluminum added, lb per ton of steel	Mean of austenite grain-coarsening temp, F	
	C	Mn	S	Al①		1-Hr treatment	4-Hr treatment
Z-1	0.19	0.67	0.04	<0.003	0.19	1600	1525
Z-2	0.19	0.68	0.04	<0.003	0.38	1675	1585
Z-3	0.18	0.68	0.04	0.003	0.75	1755	1740
Z-4	0.18	0.68	0.04	0.027	1.50	1840	1800
Z-5	0.27	0.50	0.06	<0.003	0.19	1600	1530
Z-6	0.27	0.51	0.06	<0.003	0.38	1605	1515
Z-7	0.27	0.49	0.06	0.006	0.75	1695	1640
Z-8	0.27	0.50	0.06	0.043	1.50	1785	1740
V-1	0.26	0.45	0.08	<0.003	0	1740	1640
V-2	0.27	0.45	0.07	<0.003	0.09	1725	1640
V-3	0.28	0.46	0.08	0.005	0.54	1705	1625
V-4	0.29	0.45	0.07	0.018	0.84	1790	1760
V-5	0.21	0.67	0.07	<0.003	0	1665	1535
V-6	0.19	0.67	0.06	0.004	0.09	1615	1600
V-7	0.22	0.67	0.07	0.006	0.54	1725	1715
V-8	0.19	0.66	0.07	0.017	0.84	1795	1750
W-1	0.23	0.52	0.09	<0.003	0	1650	1585
W-2	0.23	0.52	0.10	<0.003	0.25	1695	1610
W-3	0.23	0.52	0.09	<0.003	0.50	1660	1580
W-4	0.23	0.52	0.10	0.020	1.00	1765	1750
W-5	0.23	0.78	0.09	<0.003	0	1740	1630
W-6	0.22	0.80	0.08	<0.003	0.25	1680	1615
W-7	0.20	0.80	0.08	<0.003	0.50	1740	1685
W-8	0.21	0.78	0.08	0.029	1.00	1850	1825

① Acid-soluble-aluminum content.

dient in the specimens, the temperatures at which the austenite grains tended to coarsen after heating times of one and four hours could be determined.

The mean coarsening temperature for each steel is given in Table IX. Austenite grains larger than 4.5 on the ASTM scale were considered coarse. The mean austenite grain-coarsening temperature was lowered by increasing the heating time from one to four hours, indicating that the austenite grains still continued to grow after holding at temperature for more than one hour.

The effect of acid-soluble-aluminum in the steels on their austenite grain-coarsening temperatures is shown in Figure 6. An increase in the acid-soluble-aluminum content, as would be expected, increased the grain-coarsening temperatures of the steels. Nevertheless, the data show that all of the steels were coarse grained when heated for hot rolling.

INFLUENCE OF NORMALIZING ON THE PROPERTIES OF KILLED AND SEMIKILLED STEELS

Sections of six of the plates finish rolled on commercial mills were normalized by heating for one hour at 1650 F and air cooling. Three of the plates contained either no aluminum or the minimum quantity used by the supplier. These plates were, therefore, made from semikilled steels and were of Type B composition. They represented plate from each of the three suppliers. The other three plates were also of Type B steel and represented fully-killed steels from the three suppliers.

The ferrite grain size and the Charpy transition temperatures of the six steels before and after normalizing are shown in Table X. Included in the table are data on the steels in the as-received condition (as-rolled commercially) and after rerolling from 1¾ to ¾-in.

Figure 6 — The increase in the acid-soluble-aluminum content increases the grain coarsening temperatures of steels.

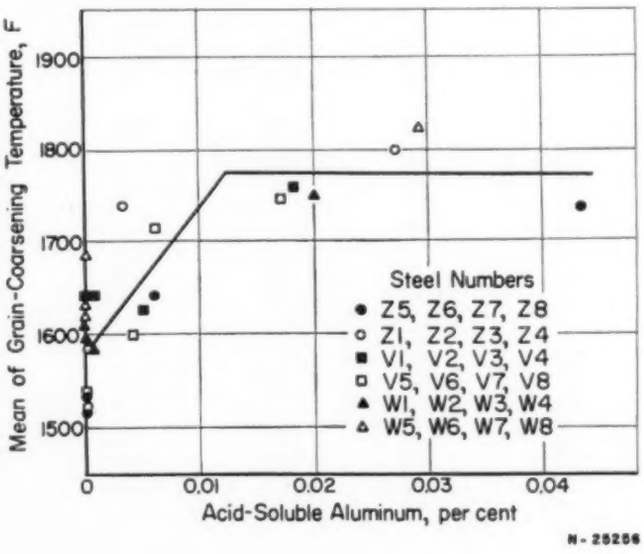

TABLE X

Ferrite Grain Size and Keyhole Charpy Transition Temperatures of Six Plate Steels in Three Different Conditions

Steels	Semikilled steels			Killed steels		
	Z-1	V-5	W-5	Z-4	V-8	W-8
Composition:						
Carbon, per cent	0.19	0.21	0.23	0.18	0.19	0.21
Manganese, per cent	0.67	0.67	0.78	0.68	0.66	0.78
Silicon, per cent	0.04	0.07	0.09	0.04	0.07	0.08
Aluminum, per cent	<0.003	<0.003	<0.003	0.027	0.017	0.029
No. of ferrite grains per 0.0001 sq in.						
Commercially rolled	67	64	66	65	58	107
Normalized at 1650 F	95	99	128	232	186	204
Finished at 1650 F	91	97	107	114	88	101
Charpy transition temperature, F						
Commercially rolled	−18	− 4	− 8	−37	−16	−37
Normalized at 1650 F	− 4	−15	−35	−81	−82	−95
Finished at 1650 F	−37	−23	−50	−53	−64	−62

plate in the laboratory using a finishing temperature of 1650 F.

Normalizing from 1650 F refined the ferrite grain size of all the plates, but the change in grain size was much more pronounced for the killed steels. The grain size of the killed steels changed about one to two numbers on the ASTM scale. On the other hand, the grain sizes of the normalized, semikilled steels were almost the same as those of plates finished at 1650 F.

The practice used for rerolling the slabs to plates and the data in Table IX explain why normalizing improved the killed steels more than it did the semikilled steels. Since all plates were heated at 2250 F or higher, for rolling, they initially had coarse austenite grains, even when the finishing temperature was 1650 F.

Apparently the air cooling of steels with coarse austenite grain sizes from 1650 F produces about the same ferrite grain size in both semikilled and aluminum-killed grades. Aluminum, however, influences the austenite grain size developed on reheating from room temperature to 1650 F. Table VIII shows that reheating to this temperature produces coarse austenite grains in semikilled steel but fine austenite grains in aluminum-killed steels. The final ferrite grain size is a function of the austenite grain size and the cooling rate which characterizes the normalizing treatment. A finer austenite grain size, other conditions remaining the same, produces a finer ferrite grain size in the steel.

The changes of ferrite grain size produced by normalizing are also reflected by changes in the Charpy transition temperatures. Plates having the finest ferrite grain sizes have the lowest transition temperatures. After normalizing from 1650 F, the three aluminum-killed had Charpy transition temperatures below −80 F.

SUMMARY

The results obtained in this investigation justify the following conclusions:

1. The resistance of hot-rolled steel plates to brittle fracture can be increased by lowering the final rolling temperature. Decreasing the finishing temperature by 100 F, in the range from 2050 to 1650 F, lowered the ductile-brittle transition temperature 6 F in Charpy tests and 8 F in tear tests.
2. Lower finishing temperatures produced smaller ferrite grains. The as-rolled grain size was independent of variations in aluminum contents up to 0.04 per cent. After normalizing, however, the aluminum-killed steels had finer ferrite grain sizes than semikilled steels. Principally for this reason, the beneficial effects of normalizing on toughness were more pronounced for aluminum-killed steels than for semikilled steels.
3. Within the range investigated, lower finishing temperatures raised the yield strength of hot-rolled steel plates. Finishing temperature had no effect on ultimate strength or elongation values.

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DISCUSSION

PRESENTED BY

LOCKWOOD LYON, Assistant Superintendent, 76-In. Hot Strip Mill, Inland Steel Co., East Chicago, Ind.

V. E. ELLIOTT, General Supervisor Research, United States Steel Corp., Gary, Ind.

R. H. FRAZIER, Assistant Chief, Division of Ferrous Metallurgy, Battelle Memorial Institute, Columbus, Ohio

F. W. BOULGER, Chief, Division of Ferrous Metallurgy, Battelle Memorial Institute, Columbus, Ohio

C. H. LORIG, Technical Director, Physical and Process Metallurgy, Battelle Memorial Institute, Columbus, Ohio

Lockwood Lyon: The authors have demonstrated without a doubt the influence of finishing temperature on the ductile brittle transition temperature of structural plates. This has been of particular interest to us since it substantiates our findings in a review of the brittle fracture work done at Inland Steel Co.

Comparing the transition temperatures that were encountered between the commercially processed plates and those treated in the laboratory, it is difficult to see that the difference in cooling rate between the two treatments was entirely responsible for the higher transition temperatures of the commercial plate. The authors cited their previous work which showed this as a possible explanation. However, in that study, the data covered cooling rates obtained by an air blast, still air, vermiculite, and furnace cooling. The latter two cooling rates (vermiculite and furnace cooling) are completely out of range of that found in commercial processing and cannot be considered. The same paper showed only a slight difference in notch impact and no difference in tear test transition temperatures between the air blast and air cooled specimens. This leads one to believe that the difference between the cooling rate of commercially processed plates and the laboratory treated samples was not responsible for the different level of transition temperatures.

As a possible factor which would contribute to the high transition temperatures and the somewhat erratic results obtained on the commercially processed plates, some consideration should be given to the differential in cooling that is encountered in a large plate. This is particularly true where the steel is handled on a cooling bed where skids are employed. A chilled area is encountered in the plate at the point of contact with the skids. The stresses thus imposed in the plate by the differential cooling through contact with the skids or other conditions that may bring about a similar situation may possibly influence the brittle fracture characteristics of the test specimens.

It should be noted that the authors omit any mention of maximum piling temperature in the normal commercial process. A study by Logan Mair of the Inland Research Department reported in the November 1954 issue of the Journal of Metals concluded that pile cooling of structural steel plates below 1100 F is not detrimental to the brittle fracture properties. In the absence of any data on piling above 1100 F, one of the problems thus presented to the operating department in improving the brittle fracture performance of the commercial structural plate seems to be the minimizing of local stresses caused by holding on cooling beds and at the same time to cool from 1600 to 1100 F *before* hot piling. In many installations these two steps are incompatible. At the Inland 76-in. mill we have had extensive experience in this problem. In rolling $\frac{5}{8}$ x 32-in. wide cartridge case plate which has severe surface requirements, the characteristics of the oxide are controlled with finishing temperatures. In addition, piling is done at 1000 F maximum in order to prevent carbide banding. By filling the run-out table and all the other handling tables and running at reduced speeds, rocking the plates back and forth when delayed, the piling problem was solved with no loss in rolling rate. The necessary cooling was found to occur in about 10 to 15 minutes after rolling. For installations with less extensive run-out tables the problem becomes quite severe. The solution lies in piling at higher temperatures or cooling at a rapid rate down to 1100 F before piling, by the use of water sprays for instance. Thus two questions left unanswered here are the effect of rapid cooling or hot piling above 1100 F on the brittle fracture properties of structural plate.

There are some rolling problems to be considered in lowering the finishing temperatures of structural plate. The finishing passes can easily be made at 1600 F. However, the heavier roughing reductions must be made at the normal higher temperatures. This introduces a cooling process in the rolling train. Our experience in this area is in the rolling of enameling iron and cartridge case. The cooling is accomplished by holding the steel after roughing on the delay table until the desired entering temperature for finishing is reached. First, there is a difficulty in measuring the temperature accurately as a flaky scale forms on the surface of the slab. This uncertainty of temperature leads to gage variations. Differences of 100 F in the 1600 F range of finishing temperature on $\frac{3}{4}$-in. plate will cause an order to run the complete spread of the commercial tolerance. The differential cooling rates of large plates on the roller tables leads to higher possibilities of cobbles in the finishing passes caused by a cold side. The scale formed in the roughing passes is harder to clean at 1600 to 1700 F than at the normal 1900 to 2000 F working temperature. Roller table maintenance is more critical when extensive holding is done. And last, production is limited by using this cooling process. The drop from 2000 to 1700 F when roughing a 6-in. slab to $1\frac{1}{4}$ in. occurs in about three minutes. However, the process employed at the 76-in. mill is to use a $4\frac{1}{2}$ or 5-in. slab, dummy the No. 4 rougher and hold slabs on two delay tables. This enables rolling 72-in. wide $\frac{3}{4}$-in. plate at 400 tons per hour with a 1600 F finishing temperature. This is far in excess of the heating or piling rates which could be maintained.

However, as in the piling problem, some installations would be slowed down too much by an air cooling process. The authors used a furnace to attain the 1650 F finishing temperature. The question of a rapid cooling

with water sprays comes up again. In order to maintain production rates this may be necessary. Therefore, the effect of rapid cooling before the finishing passes on the brittle fracture performance must be determined.

The production cost aspects of this paper therefore cannot be stated generally, but for any individual installation, center around the production rates involved in holding steel for cooling in the rolling train, holding steel for cooling before piling, possible cobble increases, off-gage rejections, and increased table maintenance.

V. E. Elliott: The authors have presented a paper of interest to those concerned with both the production and use of steel plates. We have also found evidence of this effect of finishing temperature on the properties of plates in experiments conducted at Gary Steel Works. Both semikilled and s'licon-aluminum killed steels of class B composition were tested. The procedure, utilizing a laboratory rolling mill, was similar to that described by the authors and the results were in agreement with those reported in the subject paper.

From the author's presentation, it was not clear if the difference in transition temperature between plates rolled in commercial mills and plates rolled in the laboratory was associated with a difference in grain size or some other factor associated with cooling rate. This point would perhaps be of practical significance in adapting this procedure to mill operations.

From the standpoint of cost, we do not know what would be involved in developing a practice so as to produce lower finishing temperatures of plates off the mill. However, one would expect some slowing-up of production, increased wear of facilities, and possibly poorer surface quality (because of lower rolling temperatures). Such a change would indeed have to be weighed carefully against the rather simple expedient of adjusting the carbon and manganese contents to obtain a similar improvement in notch toughness.

R. H. Frazier, F. W. Boulger, and **C. H. Lorig:** The information furnished by Mr. Lyon and Mr. Elliott is an extremely valuable contribution to the matter of supplying plate steel with minimum ductile to brittle transition temperatures. We agree with Mr. Lyon on his comment that cooling rate is not entirely responsible for the higher transition temperatures of the commercial plate. Further work in the field should certainly establish the magnitude of the effects of other operating variables.

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▲ SINCE 1936, twenty-eight high speed continuous rod and merchant-bar mills have been built and installed in the United States. Seventeen of this total are multi-strand mills.

These mills roll reheated billets into many different products such as small angles, rounds, flats, squares, hexes, structural sections, and reinforcing bar delivered over runout tables to pilers or cooling beds. When rolling rod, it is delivered to laying or pouring reels for handling in coil form. Rod is subsequently drawn into wire for such things as valve springs, cable, etc. Rod is also the supply from which rivets, bolts, and screws are made.

The multi-strand rod mills usually have 12 to 14 stands in a straightaway arrangement, with one to four stands per motor, followed by a loop, a stand with individual driving motor, another loop, another individually driven stand, a third loop and a geared finishing train of six or eight stands powered by a common motor. The theory behind this arrangement is as follows: if a good section is delivered to the finishing train, a good product will result. The looping section of the mill (where the material is free from tension) will eliminate eccentricities produced by transient speed changes in the straightaway section. The degree to which this theory is valid is not known. Actually, there are many possible variations as to millstand and motor arrangement. Figures 1, 2, and 3 show in elementary form the general arrangement of recent rod, bar, and combination rod-merchant mills. The essential difference between the merchant and rod mill is that the merchant mill has a cooling bed for straight lengths.

The use of individual drives on finishing mills such as rod or bar mills gives the advantage of flexibility which extends all the way back to the primary mills. Thus, billet mills can restrict their production to a limited range of sizes, and operate for extended periods on one size of billet.

THE PROBLEM OF IMPACT SPEED DROP

Main drive d-c motors range in size from 150 to 2000 hp. Motor speeds are preset for the particular rolling schedule to be used. The speeds are not changed as metal enters or leaves the stands, aside from changes due to motor speed regulation or minor shunt field adjustments made by the operators to control looping between stands. Rod mills are usually "multi-strand," which means that the rolls have several sets of grooves through which the bars pass, and from two to four bars may be proceeding through the mill side by side. The bars leave the heating furnace in succession, with one bar directed into the first groove, the next into the second, and so on, with only a small gap between successive bars in any one groove. The bars are large enough so that any one bar will be in all stands at the

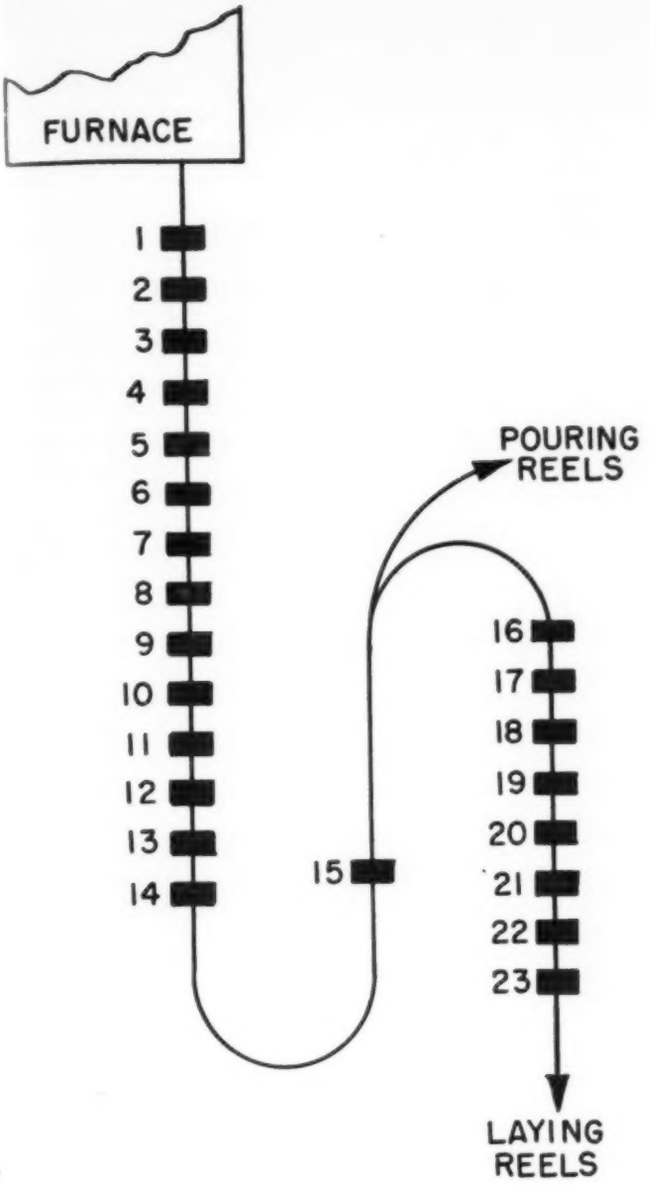


Figure 1 — Arrangement of 23-stand, 3-strand rod mill.

same time. Thus, on a two-strand rod mill the load variations will be in increments of 50 per cent whereas on a four-strand rod mill the increments would be 25 per cent. Obviously, if the motor speed changes materially due to these load changes, there will be stretching or looping of the bar which may throw it off gage, break it, or "cobble" the mill. For these reasons, close speed regulation, both impact and steady-state, is required.

During the transient speed drop period when the metal hits each stand, the suddenly applied load causes the motor speed to drop, followed by a speed recovery. Figure 4 shows the behavior of the motor during this transient period. When a mill is operated with loops between stands, an impact speed drop has little effect, and in this case motors with standard steady-state speed regulation would be suitable. Where the mill is operated without loops between stands, an impact speed drop will momentarily upset the proper speed relationship between stands and may cause stretching or excessive looping of the material between stands.

MOTOR REQUIREMENTS

In the past, it was the practice to furnish special high inertia "rod" mill motors having low resistance and inductance to give a lower impact speed drop and smaller speed recovery. Series exciters connected across the motor auxiliary shunt field and excited from motor load current were used to provide a steady-state speed error not exceeding 1½ per cent over the motor speed range. Armature circuit boosters with rotating regulator type IR drop or loop regulators have also been used to reduce the steady-state error. Today, rod mills are being furnished with standard rolling mill motors and speed regulators to minimize impact speed drop, smooth out transient swings, and reduce the steady-state speed error.

The difference in performance between a standard rolling mill motor and a rod mill motor is not remarkably large. On the rod mill design, the impact speed drop of the motor may be reduced 11 or 12 per cent, for example from a drop of approximately 4.9 per cent to one of about 4.3 per cent. The armature inductance may be reduced in the order of 25 per cent and the armature resistance about 15 per cent. The inertia of the motor may be increased about 25 per cent.

Figures 5 and 6 are comparisons of motor speed regulation at base and top speed due to impact loads with and without regulators. These figures reveal several interesting factors. With the speed regulator at top speed, both impact drop and response time are reduced while at base speed, response time and impact drop remains about the same. The steady-state speed error is considerably reduced with the speed regulator at both top and base speeds. Adding WK^2 to a standard motor does not force it to behave similarly to the low impact motor. The low impact motor has lower armature resistance and lower inductance. This combination decreases the armature loop time constant, thereby allowing the restoring torque to build up faster.

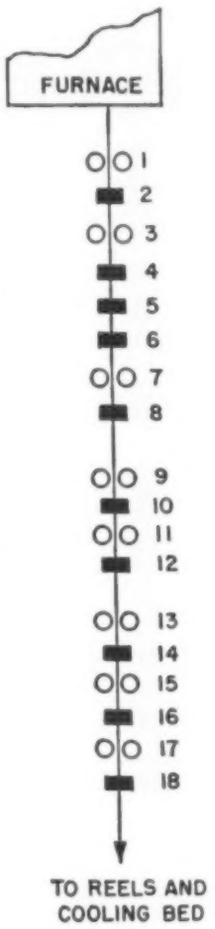


Figure 2 — Arrangement of 18-stand bar mill.

POWER SUPPLY

Rod and merchant-bar mills generally require approximately 5000 to 12,000 kva of a-c power for the main drive 600 to 750-volt d-c motors. This a-c power is usually supplied at 6900 or 13,800 volts directly to rectifier transformers or motor-generator sets. If rectifiers are used instead of motor-generator sets, the rectifier transformers can and have been supplied for higher voltages. In addition to main drive power, approximately 1500 kva of 440 volts is required for smaller a-c motors and 500 kw for 250 volt d-c requirements to handle crane and various auxiliary motors.

The power supply for the main d-c drive motors of

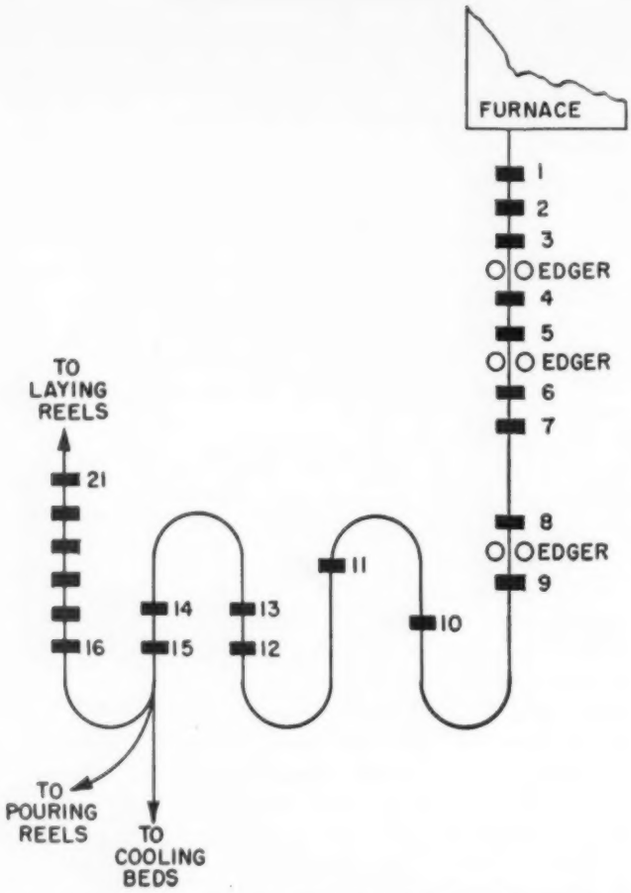
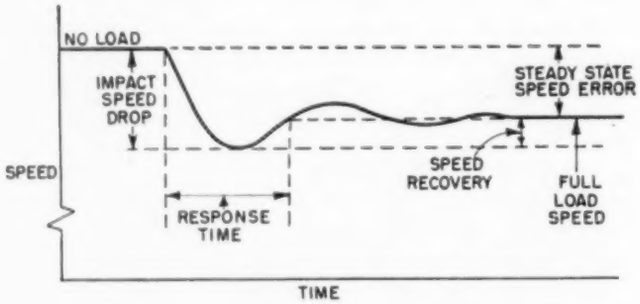


Figure 3 — Arrangement of 21-stand, 3-strand combination rod and merchant-bar mill.

a rod mill is selected on the basis of supplying the motors with a diversity factor of approximately 70 per cent. Merchant mills show more variation in this respect, the factor ranging from approximately 50 to 90 per cent on mills now installed. Table I is a tabulation of kw per hp for a number of mills.

Either or both d-c generators and rectifiers can be used as the source of main drive power on rod and merchant-bar mills. Each application has to be analyzed to determine which is the one to use. The appraisal of rectifiers versus motor-generator sets has been adequately covered in previous AISE papers. Table II gives a summary of the advantages of each. Recently, there has been a trend toward rectifier-powered mills. The last three rod mills sold in the United States will be powered by rectifiers. Two of these mills are already in service. Figure 7 illustrates a pumpless rectifier unit substation rated 3000 kw, 600-volt d-c.

Figure 4 — D-c motor speed changes following a step increase in load may upset speed relationship between stands.



Rectifiers provide the same operating features as d-c generators except they cannot regenerate, the adjustment of voltage is not as straightforward, and jogging reverse is accomplished by reversing the motor shunt field.

With rectifiers or generators, whenever the operator slows down the mill by strengthening motor field or reducing voltage, the motors must pump power back into the system or into work at the rolls. Since rectifiers will not regenerate without furnishing additional complicated equipment, load absorbing resistors called slowdown "SD" resistors are normally required. For each rectifier supplying power to one or more motors, it is necessary to have one common "SD" resistor which is energized under the following conditions:

1. It is energized continuously as a function of the master rheostat when the rectifier voltage is being reduced.
2. It is energized continuously as a function of the stand coarse rheostat strengthening motor field on rectifiers supplying only one or two motors.
3. It is energized automatically by a magnetic amplifier regulator which compares and operates as a function of rectifier voltage and motor bus volts whenever the motor stand vernier rheostat is strengthened.

Figure 8 is a copy of an oscillogram illustrating the voltage rise when a motor field is strengthened by the operator's vernier rheostat on a system having one 2000-kw, 700-volt, d-c rectifier and two 1250-hp motors

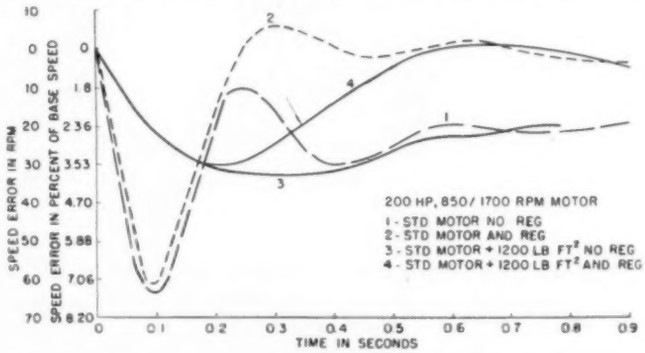
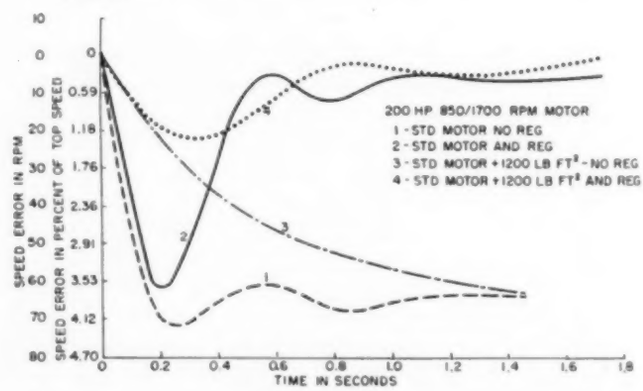

SPEED ERROR IN RPM
SPEED ERROR IN PERCENT OF BASE SPEED
TIME IN SECONDS
200 HP, 850/ 1700 RPM MOTOR
1 - STD MOTOR NO REG
2 - STD MOTOR AND REG
3 - STD MOTOR + 1200 LB FT² NO REG
4 - STD MOTOR + 1200 LB FT² AND REG

Figure 5 — Comparison of motor response with 100 per cent rated torque load added instantly at base speed — 850 rpm.

Figure 6 — Comparison of motor response with 100 per cent rated torque load added instantly at top speed — 1700 rpm.


SPEED ERROR IN RPM
SPEED ERROR IN PERCENT OF TOP SPEED
TIME IN SECONDS
200 HP 850/1700 RPM MOTOR
1 - STD MOTOR NO REG
2 - STD MOTOR AND REG
3 - STD MOTOR + 1200 LB FT² - NO REG
4 - STD MOTOR + 1200 LB FT² AND REG

with no metal in the mill. The bus voltage rose 46.5 volts above the operating voltage of 700 volts. At this point, the magnetic amplifier comparing rectifier and motor bus volts automatically energized the "SD" resistor. On a multi-motor bus with more than two motors, the other motors will generally absorb the pump-back of one motor when its field is strengthened.

Voltage adjustment of rectifiers is generally obtained in two ways: (1) by phase control which varies the time for initiating current flow on each cycle, and (2) by changing the applied a-c voltage with either open circuit taps on the rectifier transformer or with load ratio control transformers. Voltage reduction is most readily accomplished with phase control. However, with phase control, the power factor is reduced in about the same proportion as the voltage. As short intervals

TABLE I

No.	Type of mill	Delivery speed, fpm	D-c supply		D-c drive, kw per hp
			Hp	Kw	
1	Bar 18-Stand	2,600	9,900	7,500	0.757
2	Bar 16-Stand	3,500	9,000	6,750	0.750
3	Bar 18-Stand	3,300	10,200	7,500	0.735
4	Bar and rod 21-Stand, 4-strand	4,100	7,600	5,250	0.691
5	Bar and rod 13-Stand	4,500	15,100	10,000	0.662
6	Bar and rod 14-Stand, 2-strand	3,800	1,700	1,400	0.823
7	Bar and rod 20-Stand, 2-strand	4,140	5,500	5,000	0.910
8	Merchant 17-Stand	1,675	3,050	2,250	0.738
9	Merchant 16-Stand	2,200	7,925	2,500*	0.315
10	Rod and merchant 20-Stand, 3-strand	4,200	7,650	5,000	0.654
11	Rod and merchant 21-Stand, 2-strand	4,800	8,850	4,000	0.453
12	Rod and merchant 22-Stand, 2-strand	4,500	6,100	4,500	0.739
13	Rod and merchant 21-Stand, 3-strand	5,500	8,950	5,000*	0.560
14	Rod and merchant 12-Stand	2,000	5,650	4,000	0.710
15	Rod and merchant 16-Stand, 2-strand	3,400	3,900	2,000	0.513
16	Rod 20-Stand, 2-strand	4,000	5,600	4,000	0.714
17	Rod 22-Stand, 3-strand	5,000	7,100	5,000	0.702
18	Rod 22-Stand, 3-strand	4,563	7,200	5,250	0.730
19	Rod 23-Stand, 4-strand	6,000	13,500	9,340*	0.692
20	Rod 23-Stand, 3-strand	5,000	7,450	5,500*	0.740
21	Rod 23-Stand, 3-strand	4,800	7,150	4,500	0.630
22	Rod 17-Stand, 2-strand	1,675	3,050	2,250	0.692

*Rectifier power supply.

TABLE II

Advantages of Rectifiers

1 — Lower losses, results in power savings.
2 — Lower installation cost.
3 — Lower maintenance cost.
4 — Higher momentary overload capability.
5 — No fault contribution to a-c system.

Advantages of Motor-Generator Sets

1 — Power factor correction.
2 — D-c voltage does not fluctuate directly with a-c supply voltage.
3 — Inherently provides lower voltages for continuous operation.
4 — Ability to regenerate on pump-back loads.
5 — No problem of telephone interference.

of low power factor are usually not too objectionable, phase control of rectifiers is normally used to start motors from rest. If such lower power factor for an extended period is objectionable, the alternative is to reduce the a-c voltage applied to the rectifiers by changing transformer taps, reserving the phase control for vernier adjustment between taps. In most cases, the desired voltage may be selected before the mill starts and no load taps can be used. If it is necessary to change transformer taps while the mill is running, the transformer must be equipped with load ratio control. Figure 9 shows a schematic one-line diagram of a rectifier system with load ratio control for transformer tap changing under load.

Transformer tap changing under load using load ratio control equipment produces sudden small change in both the transformer secondary a-c and rectifier d-c voltages. Although the d-c voltage regulating system has a high speed of response which tries to minimize these disturbances, it is best to limit each voltage tap change to not more than 1.25 per cent of the maximum continuous bus voltage.

FAULT CURRENTS ON D-C SYSTEMS

There are many ways the machines and bus sections can be arranged. An inspection of the rolling schedule calculations will determine whether bus sectionalizing breakers are needed and where they should be located to permit operation at different voltage levels. In general, breaking the system into several smaller bus sections is good since it reduces the fault currents that can flow. If a common bus is used for the complete mill, it is usually desirable to split the system when fault currents flow by means of a high-speed bus sectionalizing breaker. However, on rectifier systems, these bus sectionalizing breakers must be specially relayed so that they will not trip on rectifier arc-backs, but only on faults such as flashed machines. The two most recent operating rod mills which were powered by rectifiers had three separate bus sections each with no bus tie breakers.

Heavy fault currents on mill d-c systems generally start with flashed-over machines or starting dead machines on an operating bus. In the final analysis, it is the machines that are to be protected by the breakers, and it is usually the series winding (pole face and commutating pole) which fail on heavy fault currents. The series windings of a main drive d-c motor are normally designed to withstand the current that will flow when its terminals are short-circuited, which is from 10 to 20 times rated current, but no more.

Calculating short circuit currents for a d-c system with rectifiers and motors present is a relatively complicated problem. It involves developing an equivalent rectifier source having an equivalent resistance and inductance to be used as constants for calculating d-c fault currents. Once these values are determined, the sustained fault current, the peak fault current, and the rate of rise of the fault current can be calculated. Figure 10 summarizes the steps for making an approximate calculation of circuit characteristics for a rectifier powered system and tabulates the fault current to be expected.

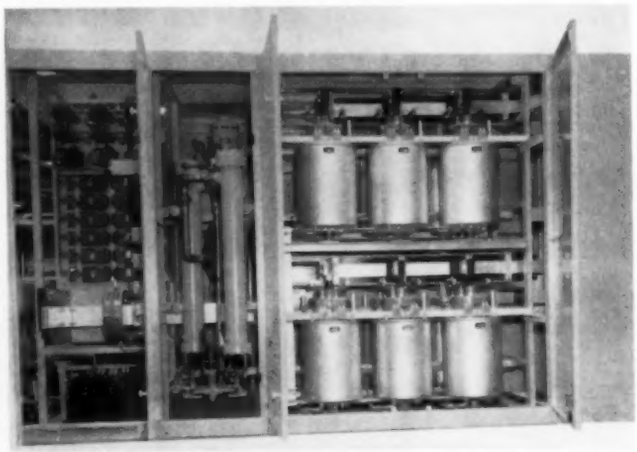


Figure 7 — This 3000-kw, 600-volt, d-c pumpless rectifier substation has stainless steel tanks and dual ignitors.

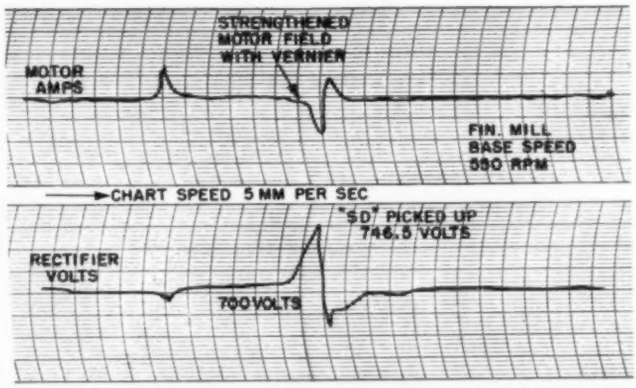
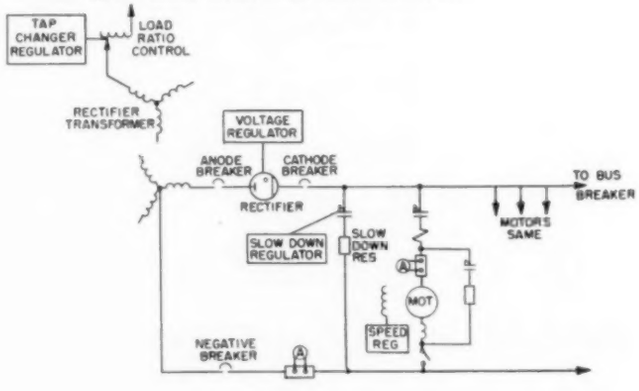
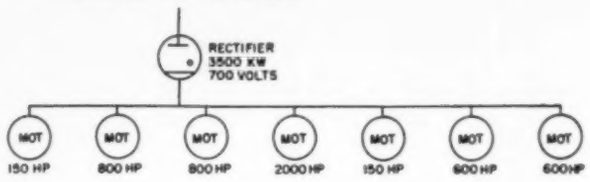

STRENGTHENED MOTOR FIELD WITH VERNIER
MOTOR AMPS
FIN. MILL BASE SPEED 550 RPM
CHART SPEED 5 MM PER SEC
"SD" PICKED UP 746.5 VOLTS
RECTIFIER VOLTS
700 VOLTS

Figure 8 — Oscillogram illustrates voltage rise when motor field is strengthened on system with one 2000-kw, 700-volt, d-c rectifier and two 1250-hp, 575/980-rpm motors.

Figure 9 — Simplified schematic of rod mill drive system using rectifier with load ratio control.



A- SIMPLIFIED ONE LINE DIAGRAM



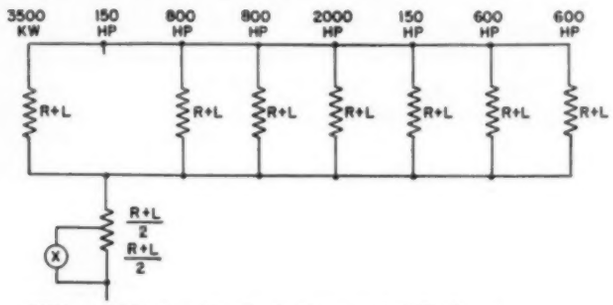
B- MACHINE DATA

Machine	Full Load Amps	Armature Transient Resistance Ohms	Armature Inductance Milli-Henries
150 HP	174	0.32	24.6
600 HP	695	0.0655	1.098
800 HP	925	0.0588	0.7965
2000 HP	2300	0.0264	2.8862

3500 KW, 700 VOLT D-C RECTIFIER

Full Load Current ---------- 5000 Amps
I max. (peak)(approx.)--------- 5000 x 20 = 100,000 Amps
I max. (sustained)(approx.)---- 5000 x 14 = 70,000 Amps
Current Rate of Rise --------- 5000 x 4000 = 20 x 10^6 Amps/Sec (approx.)
Equiv. Resistance (approx.)---- $\frac{700}{70,000}$ = 0.01 Ohms (For motor fault)
Equiv. Resistance (approx.)----- $\frac{700}{100,000}$ = 0.007 Ohms (For Bus fault)
Equiv. Inductance (approx.)---- $\frac{700}{20 \times 10^6}$ = 35 x 10^6 Henries (For motor or bus fault)

C- REACTANCE DIAGRAM OF SYSTEM ASSUMING MOTOR FAULT ON 150 HP MOTOR AND RESULTS OF CALCULATIONS.



NOTE: Neglect cable resistance and inductance.
Assume flashover on 150 HP motor.

Overall Equiv. Resistance--0.16408 ohms
Overall Equiv. Inductance--0.01233 henries
Max. Fault Current -------- $\frac{700-50}{0.16408}$ = 3950 Amps
Current Rate of Rise------- $\frac{700-50}{.01233}$ = 52700 Amps/Sec
Motor Contribution -------- 1930 Amps
Rectifier Contribution ---- 2020 Amps

Figure 10 — Approximate fault current calculation for rectifier powered d-c system.

VENTILATION

Ventilation for removing heat and supplying clean air to the electrical equipment is necessary for continuous and uninterrupted service. Ventilating equipment for the motor room and forced ventilated machines is normally selected on the basis of supplying 120 cfm of air per kw loss. Typical ventilating air requirements for two recent installations are shown in Tables III and IV.

A recirculating or non-recirculating ventilating system may be used for equipment located in the motor room with a non-recirculating system for equipment located in the mill area. On rod, bar and merchant mills, clean air must frequently be provided for motors which cannot be readily connected to the main system due to their physical location. In these cases, it may be necessary to furnish an independent complete ventilating system at the motor. The main drive d-c motors on one rod mill were totally enclosed water-air-cooled (integral ventilated), complete with separate fans, carbon dust filter, water-to-air heat exchanger, and plenum chamber designed as a part of the motor base.

The exact ventilating system to be used will vary with the size of the motors and with the physical conditions of the installation. The paper "Ventilation of Steel Mill Equipment," by S. L. Jameson, 1955 Proceedings AISE, provides a recent complete review of the topic, including a discussion of integral ventilated motors.

SPEED CONTROL SYSTEM

On several recent rod mills a new type of speed matching mill drive system has been successfully used. This system utilizes standard rolling mill type motors and speed regulators for each drive. A 5500-fpm, 3-strand rod mill using this new control system went into operation late in 1955. The control system was designed to hold 0.25 per cent steady-state speed error and to have an improved response time over previous systems. Three 700-volt, d-c pumpless mercury arc rectifiers, one each for the entry, intermediate, and the delivery sections of the mill, with no bus ties, supply power to the main drive motors on this mill.

TABLE III

Ventilating Air Required for Rectifier-Powered Rod Mill, Non-Recirculating System

Total main drive rectifiers ..... **5000 kw**

Total main drive motors ..... **8950 hp**

Description	Fan cfm
Supply fans	96,000
Motor fans	83,100

TABLE IV

Ventilating Air Required for M-G Set-Powered Rod Mill, Recirculating System

Total main drive m-g sets ..... **5250 kw**

Total main drive motors ..... **7200 hp**

Description	Fan cfm
Make-up fans	28,000
M-g set fans	51,000
Motor fans	45,868

A schematic of the reference voltages for the rectifier and stand regulators is shown in Figure 11. The source of stand speed and rectifier voltage references is a 250-volt, d-c constant potential exciter which has its voltage regulated by a standard carbon-pile regulator. All reference voltages are raised simultaneously from zero to a preset value by means of the mill motor-operated master rheostat designated MRH. This rheostat always moves without stopping from zero to 100 per cent travel to accelerate the mill and automatically resets to its down position when the mill is stopped, which is by dynamic braking only. The voltage signal from the master rheostat is supplied to each of the three rectifier motor-operated rheostats (RRH).

Each of the rectifiers is suitable for 15 per cent continuous voltage reduction by phase retard. In addition, each rectifier transformer is equipped with three 5 per

cent taps below rated voltage. In this case, a primary open circuit manual tap changer was furnished. In order to adjust the regulator reference to compensate for this change, a selector switch on the master control panel must be turned to a position corresponding to the selected transformer taps. The voltage signal from each rectifier rheostat (RRH) is supplied to its rectifier voltage regulator and to each of the speed regulators of all stand motors connected to the rectifier.

Each stand reference consists of a motor-operated rheostat (SSRH) to provide adjustment over the motor speed range, and a 10 per cent manual vernier rheostat located on the operator's desk in the mill pulpit.

Referring to Figure 12 it can be seen that the speed regulator compares the feedback voltage of a tachometer generator driven by the main drive stand motor with the reference voltage. The resultant signal is amplified by magnetic amplifiers connected in push-pull and applied to the control fields of a rotating amplifier connected in series with the motor shunt field. The stand speed rheostat has a total of four dials. The dial in the comparison circuit provides the very important function of programming regulator gain with respect to the speed reference setting in order to maintain the same system steady-state speed error and response time over the speed range of the motor. For a given steady-state speed error, the field current regulator will require a much higher gain at base speed than at top speed. The dial in series with the motor shunt field permits the rotating amplifier to operate near zero

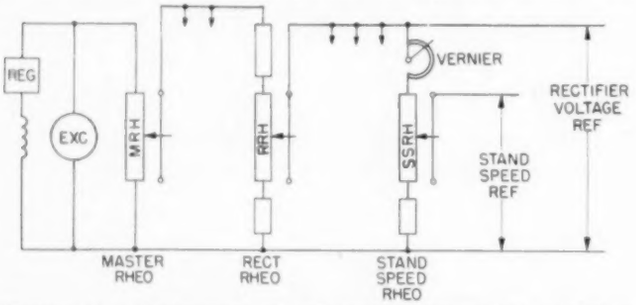


Figure 11 — Schematic of reference voltages for rectifiers and stand speed regulators.

volts at all motor speeds. A dial not shown provides rheostat position indication for the operator.

In a high gain regulating system with a fixed reference, only a change in the feedback signal can affect the output. To obtain required performance, it is important that the tachometer generator supplying this feedback signal be steady and free of ripple. As a result, permanent magnet tachometer generators having a low thermal constant and minimum ripple of output voltage were used. These tachometer generators were directly coupled to their motors with anti-backlash couplings to prevent any difference in transient and steady-state conditions caused by backlash.

The electronic computer proved itself invaluable in developing the speed regulating system. The mill was "run" on the computer and the effect of metal entering a stand "cranked" into the computer studies. During these runs, trial adjustment of circuit gains and stabilizing components were quickly made to evaluate their effect on system performance. As a result, all resistor and capacitor settings were close to their final values before the equipment was installed, and the proper

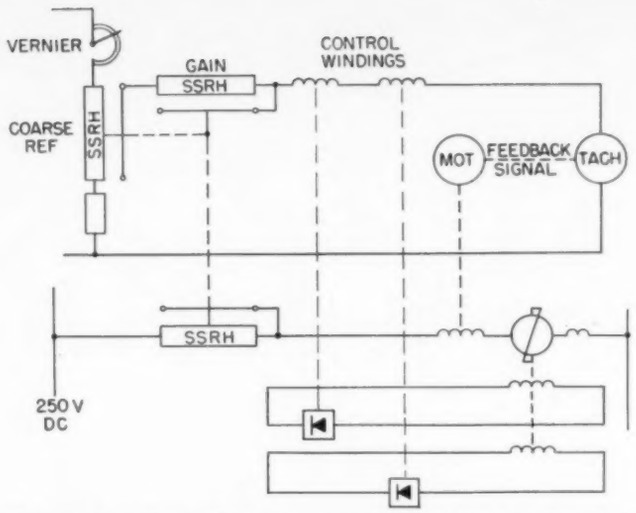


Figure 12 — Rod mill motor speed regulator has a combination system of magnetic and rotating amplifiers.

adjustments were more easily determined at the time of start-up. Since it was possible to correlate the effect of operating the mill with and without metal on the computer, the tune-up of the individual stand regulators during installation was made under no-load conditions with the motor uncoupled from the mill drive. Thus, the main drive systems were ready to go into operation without waiting until the entire mill was ready to operate.

The advantages of the speed regulator system over the previous systems are:

1. Faster recovery from impact loads.
2. Improved steady-state speed regulation.
3. Fast response to vernier adjustments.
4. Minimum speed drift over long periods.

Oscillograms of load amperes and speed versus time taken on a 500-hp, 200/600-rpm intermediate stand motor during two- and three-strand operation showed excellent results. The actual response times and impact speed drops checked the expected results predicted by the computer. The steady-state speed error was less than 0.25 per cent with no visible speed drift.

SUMMARY

With today's analytical know-how, operating experience, and available regulating equipment, it is possible to specify the machine characteristics, select the proper control system, and predict the overall system performance. As a result, the equipment goes into service quickly and performs as predicted to achieve improved product-quality and increased output with reduced unit product cost.

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By M. S. CLARK, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

Additives in steel mill lubricants

. . . . additives can improve many of the lubricants' properties and also give much longer life to the lubricant . . . . many factors must be considered and the use of additive concentrates should always be under laboratory control . . . .

▲ A lubricating oil additive has been defined as a chemical compound which imparts new properties to an oil or which improves those properties which the oil already has. These additives are not always simple chemical compounds; many commercial additives are mixtures and sometimes the exact chemical structure of the active ingredients is uncertain. Comparatively small concentrations of additive in the range of 0.01 per cent to 5.0 per cent are usually sufficient to provide the desired effect.

Additives have been used in lubricants quite extensively for the last twenty years and their use seems to be increasing. This is primarily due to the modern tendency to speed up machines to the point where additives are necessary to lubricate properly under extremely heavy duty conditions. The day may not be too far distant when practically all lubricants will contain additives of one kind or another.

It is estimated that approximately half the lubricants used in steel mills now contain additives. Table I will show types and functions of additives which may be found in steel mill lubricants.

In the above tabulation approximately a dozen different types of additives are mentioned. Each one has a specific purpose and they have all proven to be effective in laboratory tests and in plant operations. The following will give some of the theories used to explain why these materials are effective.

EXTREME PRESSURE AGENTS

It is of paramount importance that a lubricant maintain a film between moving metal surfaces. Under operating conditions where the loads are low and clearances are relatively large, the problem is simply one of selecting the proper viscosity grade of oil. In service where pressures are high, however, as in hypoid gear lubrication, the lubricant is forced out and seizure of the metals may occur. Extreme pressure agents were developed to eliminate seizure and impart the necessary high load carrying properties to the lubricant.

Several types of compounds have been found to increase the load carrying properties of lubricants. Certain phosphorus, sulphur and chlorine compounds are very effective in reducing welding. Lead compounds such as lead oleate or lead naphthenate are also effective extreme pressure agents. Certain combinations of two or more of the above often provide increased effectiveness.

When bearings or gears are operating under "thick film or hydrodynamic" lubrication there is a sufficiently thick oil film to keep the surfaces apart and extreme pressure lubricants are not necessary. However, when loads are increased greatly or when speeds are decreased and "boundary" lubrication conditions exist, the high spots on bearing or gear surfaces begin to rub each other and high localized temperatures will develop (estimated as high as 1800 F with steel on steel surfaces). If these conditions continue, the surface will get increasingly hotter and seizure will eventually take place. Under these conditions, extreme pressure additives react chemically with the hot steel forming sulphide, chloride, phosphate or lead compounds on the hot spots. These compounds protect the steel preventing seizure and inducing lower temperatures.

VISCOSITY INDEX IMPROVERS

The physicist defines viscosity as a measure of the relative fluidity of a liquid at some specific temperature. Viscosity will vary inversely with temperature, i.e., the colder the oil, the heavier or more sluggish it will become. As the temperature is raised, the same oil will become more and more fluid. Viscosity index indicates the rate of change of the viscosity of a lubricating oil with temperature. The higher the viscosity index, the less the viscosity of the oil changes with temperature.

Viscosity index by itself is not indicative of the oxidation stability or performance qualities of a lubricating oil. Low viscosity index oils may give as good performance as high viscosity index oils. In machinery where starting temperatures are unimportant, such as stationary engines operated inside buildings, low viscosity index oils have been used extensively for years with excellent results.

In order to be able to extend the usable temperature range for oils for automotive engine service, and for hydraulic oil systems, however, where starting and operating temperatures are sometimes quite low, it has been found necessary to develop viscosity index improvers. These materials usually consist of high molecular weight compounds or polymerized materials. The effect of such materials is illustrated in Table II.

This data shows that by use of a viscosity index improver the viscosity at elevated temperatures within the operating range can be raised to assure more body

TABLE I

Types of additives in steel mill lubricants

Steel mill lubricants	Types of additives they may contain	Purpose of additives
Extreme pressure (EP) greases	Sodium, calcium, lithium soaps Lead, sulphur, chlorine or phosphorus compounds Polar compound Oxidation inhibitor	Thickening agents Withstand extreme pressure Improve lubrication especially in presence of water Resist oxidation
High temperature greases	Clay, silica or bentonite Oxidation inhibitor	Thickening agent and to provide high dropping point Resist oxidation
Roll neck greases (hand packed)	Calcium soap Graphite	Thickening agent Assist in rough lubrication
Cup greases	Calcium soap	Thickening agent
Ball and roller bearing greases	Rust inhibitor Sodium, lithium or mixed calcium and sodium soaps Oxidation inhibitor	Prevent rusting in presence of water Thickening agent Resist oxidation
Gear oils (EP) heavy duty	Lead, sulphur, chlorine, phosphorus compounds Polar material Rust inhibitor Anti-foam compound	Withstand extreme pressure Improve lubrication Prevent rusting in presence of water Minimize foaming
Gear oils (cutback)	Petroleum thinner, chlorinated solvent or coal tar solvent	Provide ease of application
Heavy duty motor oils and diesel lubricating oils	Pour depressant Viscosity index improver Anti-foam compound Detergent Oxidation inhibitor Corrosion inhibitor	Permit easy cold weather starting Minimize foaming Keep engines clean Resist oxidation Prevent bearing corrosion
Turbine oils	Oxidation inhibitor Extreme pressure agents Rust inhibitor Anti-foam compound	Provide long oil life Withstand extreme pressure Prevent rusting in turbines Minimize foaming
Steam cylinder oils (compounded)	Fatty materials such as tallow, lard or degras Pour depressant	Provide better lubrication of cylinders under wet steam conditions Permit easier handling at low temperatures
Rustproofing or slushing oils	Polar materials or emulsifiers	Protect steel from rusting
Rustproof compounds (heavy)	Polar materials, emulsifiers or certain salts	Protect steel from rusting
Thread compounds	Powdered lead, copper, zinc and graphite	Prevent galling of threads Provide good seal under pressure
Roll oils	Palm oil, tallow or other polar additives Soluble oil or other emulsifiers	Prevent scratching and provide good surface finish Provide ease of emulsion formation
Soluble oils	Water soluble soaps and sulphonates and other emulsifiers Bactericide Extreme pressure agents Rust inhibitor	Provide stable emulsions Eliminate bacterial action in emulsions Withstand extreme pressure Prevent rusting of parts being processed
Cutting oils	Sulphur, phosphorus, chlorine compounds Polar material	Withstand extreme pressure Give adhesion to metal
Quenching oils	Polar materials and other wetting agents	Provide quick wetting of hot metal

in the oil film; yet the same oil at temperatures over the cold starting range will be sufficiently fluid to assure easy starting and distribution throughout the oiling system.

POUR POINT DEPRESSANTS

The pour point of an oil is the lowest temperature at which the oil flows under conditions established by the ASTM procedure. Some lubricating oils contain wax, the presence of which raises the pour point of the oil. Although the problem of pour has always been more or less in the minds of oil refiners and equipment users, the need for oils which would flow freely at extremely low temperatures was emphasized during World War II by Army Ordnance, inasmuch as some army equipment had to be used in very cold climates. Wax is removable by various methods, but in order to avoid the excessive costs involved where drastic dewaxing operations are needed, and at the same time to retain this high viscosity index material, pour depressants have been developed which reduce the pour point of wax-containing lubricants.

Examples shown in Table III indicate how such additives, which are usually very high molecular weight condensation products, effectively reduce the pour point of an oil.

TABLE II

Effect of Viscosity Index Improver on Viscosity of Oils

Viscosity index improver, per cent added	Saybolt universal viscosity at		Viscosity index
	100 F	210 F	
0.0	350	49	26
0.5	440	54	51
1.5	600	66	86

Although a number of theories have been advanced to explain how pour depressants function, the most widely accepted one is that these materials coat the surface of the minute wax crystals. In this way both crystal growth and oil absorption by the wax are prevented at reduced temperatures. As a result, no gel formation occurs and the oil is free to flow at low temperatures.

DETERGENTS

The dictionary defines the action of detergency as the cleansing or purging away of foul or offending matter. Detergents were the first type of additives to be used in diesel engines back in the '30's for the prevention of ring sticking and piston scuffing. The term detergent has since been used to classify additives which have the property of preventing the build-up of any deposits, or removing those already formed (be it sludge, varnish, lacquer, or carbonaceous products)

TABLE III

Effect of Pour Point Depressant on Oils

Composition	Pour point, F
SAE 30 motor oil "X"	+30
SAE 30 motor oil "X" plus 1.0 per cent pour depressant "A"	−10
SAE 30 motor oil "Y"	+20
SAE 30 motor oil "Y" plus 0.16 per cent pour depressant "B"	−15

which interfere with the efficient operation of internal combustion engines. These materials, which originate from oil deterioration as well as from combustion chamber blow-by, are quite a problem particularly in heavy duty equipment.

Various metallo-organic compounds such as phosphates, phenolates, alcoholates, naphthenates, and sulphonates have been found very useful for this purpose. At one time the belief existed that only certain soaps or salts of the alkaline earth metals (calcium, barium, magnesium, and strontium) were effective as detergents. Later developments, however, have revealed that high molecular weight soaps or organic salts of a number of other metals, such as tin and cobalt, also possess this desirable property.

The exact mechanism whereby a detergent functions is not too well understood, but it may involve either one, or both, of the following preventive actions, in addition to the possible cleansing action usually attributed to it.

1. Detergents may act as oxidation directors so as to cause soluble oxidation products to form rather than oil insoluble ones.
2. A chemical reaction may take place between the detergent and the potential lacquer, and sludge-forming molecules which prevents them from becoming insoluble materials to be deposited on various engine parts.

These additives apparently have the effect of preventing deposit formation as well as providing cleansing action. Detergents serve a very important function in promoting the engine cleanliness properties of lubricating oils especially for high-speed automotive and diesel equipment.

DISPERSANTS

The action of dispersion in a lubricating oil is of a physical nature in that the products of fuel combustion, chiefly soot, along with some oil decomposition products are held in suspension in the oil. This appears to be accomplished by the breakdown of these contaminating particles into a finely divided state, or maintaining them in their original colloidal state. By this action, agglomeration of the particles is prevented with the result that oil filters and strainers remain unclogged for longer periods of time, and are thus better able to perform their function of removing from the oil stream any materials (such as dust) which might act as abrasives in the engine.

ANTI-CORROSIVES

With the continuation of improvements in automotive and diesel engine design permitting the development of more power for the equivalent size and weight engine, new materials were necessary to withstand the higher stresses imposed. Chief among these was the improvement of bearings. The demand for greater load carrying capacity and higher fatigue resistance fostered the development of bearing metals other than babbitt; i.e., copper-lead, lead plated, silver, cadmium-silver, and cadmium-nickel alloys.

It was found, however, that some of these bearings (especially copper-lead) were susceptible to corrosion by the straight mineral oils in use at that time, especially at the high temperatures obtained in automotive and high-speed diesel engines. Corrosion of bearings is generally attributable to a reaction between the acidic products of oxidation and one of the constituents of the bearing metal. For example, the mild acids formed by the oxidation of the oil will attack the lead in copper-lead bearings taking it into solution and leaving a porous copper structure which will eventually crumble and break away.

Bearing corrosion may be controlled either by inhibiting oxidation completely so that no acidic bodies are formed or by laying down a protective film on the surface of the bearing so as to prevent the acids from reaching the metal. Materials which function by forming such a protective coating are known as anti-corrosives or corrosion inhibitors. Compounds containing active sulphur, phosphorus, or nitrogen show the most promise in this respect. Materials containing sulphur seem to be especially effective due to their ease in forming protective films. These anti-corrosives may take the form of organic sulphides, phosphites, metal salts of thiophosphoric acids, and sulphurized waxes, to name a few.

It should be pointed out that anti-corrosives by virtue of their film-forming properties may also function as "poisons" for other metal surfaces in an engine. As a result, since the catalytic effects of the metal parts are decreased, the degree of oil oxidation may be reduced materially. It is obvious, therefore, that when anti-corrosives are used in conjunction with anti-oxidants, bearing corrosion is reduced, while at the same time the life of the oil may be extended more than if an anti-oxidant were used alone.

ANTI-OXIDANTS

Anti-oxidants are often added to motor oils, diesel lubricating oils and heavy duty gear lubricants and greases, all of which are used quite extensively in steel mill lubrication.

A satisfactory lubricant must possess a number of characteristics, one of the most important of which is resistance to oxidation. Any lubricant which is exposed to oxygen (or air) at any temperature will eventually oxidize. The length of time before this takes place and the extent to which it occurs depends on a number of factors, including temperature, presence of catalytic metals, presence of oxygen and the inherent ability of the oil to withstand oxidation. The products of oxidation are complex materials some of which may cause corrosion in copper-lead bearings.

Prolonged oxidation of the oil results in formation of sludge which can cause clogging of oil lines and filters and which may make ball or roller bearings inoperative. The oxidized materials may, under high temperature conditions, link together to polymerize to form lacquer or varnish on pistons, cylinders and other engine parts. Oxidation is promoted by the catalytic effect of certain metals, particularly iron and copper.

Additives which increase the resistance of an oil to oxidation are called anti-oxidants. Many of the best types are organic compounds containing sulphur, phosphorus or nitrogen, such as organic sulphides, phosphates or amines. The mechanism by which these additives function is not too well understood. However, it is possible that the additive accepts oxygen in preference to the oil. Eventually, after extended use, the additive will become depleted and the oil itself will begin to oxidize.

There are laboratory tests that will predict the effectiveness of an anti-oxidant additive. In one such test oil is heated for 40 hours at 338 F. After addition of 1 per cent additive to a straight mineral oil the amount of oxygen absorption was reduced by 70 per cent.

ANTI-FOAM AGENTS

Oils used in gears and other equipment where the oil gets whipped with air are apt to form foam which may cause oil to boil out of the crankcase.

It has been found that minute quantities of certain types of silicones have the unique effect of "breaking" the foam as soon as it is formed. This is probably a surface tension phenomenon.

POLAR MATERIALS

Fatty or other polar materials are useful in lubricants when load and speed conditions are severe and close to boundary conditions, and on the verge of needing an extreme pressure agent.

These polar or oiliness agents are usually high molecular weight materials containing carbon, hydrogen and oxygen as compared to mineral oils which contain only carbon and hydrogen. The polar oils also differ from mineral oils in one other respect, namely, that one end of the molecule is highly reactive and has the power of forming a powerful bond with the metal surface. These agents are called polar because molecules are attracted to metal much as iron filings are attracted to the poles of a magnet. The polar material is "adsorbed" to the metal surface so powerfully that the last traces can be removed by nothing short of grinding. The molecules attach themselves to a surface endwise and stick out like the flexible bristles of a brush.

This is not just a flight of fancy. Physical measurements have shown that polar molecules act in this way. The polar molecules of oleic acid, for instance, have been measured and found to be approximately one ten millionth of an inch in length.

SOAPS IN GREASES

Oil soluble, calcium, sodium, lithium and lead soaps are the ones usually used in manufacture of steel mill greases.

Calcium soap greases are comparatively insoluble in water and have low dropping points, usually around 200 F.

Sodium soap greases are soluble in water to some extent and have high dropping point, usually around 400 to 450 F.

Mixed base (Sodium and Calcium) greases have solubility and dropping point characteristics intermediate between the above two.

Lithium soap greases are less soluble in water than sodium base type but they have dropping point tests of around 350 to 450 F.

Lead soaps are usually added to greases to provide extreme pressure qualities in conjunction with sulphur or chlorine compounds.

SOLVENTS

Solvents or thinners are sometimes added to heavy, viscous type gear lubricants to thin them and make them easy to apply. The thinners evaporate during operation leaving a heavy lubricant coating on the gears.

Three types of solvents are used:

Petroleum thinners such as naphtha or Stoddard solvent are less volatile than gasoline. Their chief disadvantage is that they are flammable.

Chlorinated solvents such as trichlor ethylene have the advantage of being non-flammable but fumes may be toxic to operators if used in enclosed places.

Coal tar solvents such as benzol, toluol or xylol are also used. They have two disadvantages: they are flammable and toxic.

BACTERICIDES

Bactericides are often added to soluble oils to prevent formation of bad odor producing bacteria in emulsions. The bacteria usually originate from the water or from other outside contamination. The soluble oils themselves do not contain bacteria.

RUST INHIBITORS

Several types of inhibitors are used in slushing oils, rustproofing oils and heavy rustproofing compounds to protect against rusting in presence of water.

1. Fatty or other polar materials have the property of plating out on metal providing a protective film.
2. Emulsifying materials such as sulphonates or water soluble soaps permit water to be emulsified. This keeps the water from contact with metal.

Certain types of salts also protect against water corrosion, forming complex coatings which prevent further rusting.

SOLIDS

Finely powdered copper, zinc, lead and graphite are often blended with greases to make pipe thread lubricants. The solids prevent galling of threads when joints are tightened and they provide sealing action against high pressure. They also facilitate unjoining of pipe when dis-assembly becomes necessary.

Calcium carbonate, zinc oxide, talc and graphite are also used in hot punch compounds in shell manufacture. The solid material prevents metal to metal contact, provides good finish and facilitates removal of punches from cavities.

Recently molybdenum disulphide has received considerable attention as a solid type additive in greases and oils. Although some very interesting results have been claimed for this material, the real benefit to be gained is still a subject of considerable investigation.

The demand for high dropping point greases suitable for hot applications has led to the use of solid thickeners such as clay and silica to replace soaps. These greases have found acceptance in steel mills for lubrication of coke oven doors, cooling bed bearings and other very hot locations.

MISUSE OF ADDITIVES

The application of additives to lubricants should be a very carefully controlled procedure.

The lubricant manufacturer has many factors to consider. Some oils are more difficult to inhibit than others. Too much additive is a waste of money and may actually degrade an oil. If more than one additive is used, the effect of one must be balanced carefully against the others so that the maximum of results will be obtained.

The use of additive concentrate in used or reclaimed oils should be always under laboratory control and "know-how" since the balance may be faulty, too much may be used or the oil may be degraded instead of improved. In general such practice should be discouraged, since a careful economic study will usually reveal costs exceed savings.

SUMMARY

The petroleum industry is striving continuously to provide the highest type of lubricants to handle the extremely heavy duty service required by the steel industry. This is one way to increase production, reduce maintenance, lower unit costs—and make life more bearable for the lubrication engineer in the mill!

DISCUSSION

PRESENTED BY

N. I. WHITELEY, Lubrication Engineer, American Steel & Wire Division, United States Steel Corp., Cleveland, Ohio. (Deceased)

M. S. CLARK, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

G. H. DAVIS, Staff Engineer, Shell Oil Co., New York, N. Y.

G. C. ALMASI, Lubrication Engineer, Crucible Steel Co. of America, Midland, Pa.

JOSEPH R. SADOWSKI, Lubrication Supervisor, Crucible Steel Co. of America, Syracuse, N. Y.

ANDREW E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Construction & Engineering Departments, Bethlehem, Pa.

N. I. Whiteley*: Mr. Clark is to be congratulated on a clear and concise description of the various additives used in steel mill lubricants, their purpose and the reasons for their use. Oil suppliers have done an excellent job in supplying these additives to meet various conditions in steel mill lubrication. In most steel mills you will find lubricants containing most if not all of the additives mentioned.

Why are these necessary? Higher loads, speeds and increased production have resulted from these additives. These are the most important reasons. I would like to comment on a few of the lubricants containing additives that are widely used in steel mills today.

Extreme pressure gear oils—These lubricants containing lead, sulphur and sometimes chlorine are widely used throughout the steel industry due to increased loads on gears. Pitting and galling have been greatly reduced by these lubricants.

All of these lubricants are not alike, however.

The stability of the additive in service is very important. Water is always prevalent and some steel mills use centrifuges to eliminate the water. Some leaded products cannot be centrifuged without throwing out the lead.

Chlorine will dissipate under heat and agitation over a period of time and the extreme pressure quality drops. Some products show up well under laboratory test, but not in service over a long period of time. These gear systems are not changed as a rule, but only make-up added to account for leakage losses. So the first fill has to be with a good stable oil.

When switching to another supplier of extreme pressure gear lubricant it is not wise, in my opinion, to mix oils with chemical additives. The compatibility of these oils is open to question and fixed responsibilities are lost when mixtures are made. It is better from the steel mill standpoint to flush out the old oil and start with the new supplier's oil. If anything goes wrong you at least have a chance of fixing the responsibility.

Oxidation inhibitors—Oxidation inhibited oils are widely used in circulating systems in steel mills due to long service life expectancy. Ten or twelve years is not uncommon and filtration can extend the useful life of these oils still further.

*Deceased.

Mixing of these oils is not too critical and this has been done but again you lose the fixed responsibility.

Many oxidation inhibited oils are also rust inhibited. If good water separation is desired, for some oil type bearings, the rust inhibitor is undesirable, as good water separation cannot be obtained. The lubrication engineer must decide whether the rust inhibitor is more important or good water separation. If water is a factor it is best to use an oil with oxidation inhibitors only.

Clay filtration will also remove rust inhibitors but not oxidation inhibitors.

Antifoam agents—These are necessary in most circulation system oils due to water and entrapped air. Pump slippage also has been known to aerate an oil so the reservoir overflows. Antifoam agents will prevent this. These agents are also important in quenching tanks as foaming is very prevalent there. If any gear case foams, a few drops of antifoam agent, will quickly dispel the foam.

Detergents and dispersants—The biggest use of detergents and dispersants in steel mill lubrication is in diesel and automotive equipment, such as shop tractors. Due to dirty, atmospheric conditions, it is necessary to use oils with these qualities. Many mechanical difficulties have been eliminated by their use.

Much could be written about the benefits of additives to steel mill lubrication, but the fact that lubrication has been improved and production increased is testimony enough as to their value.

I would like to call particular attention to the part of the paper: "Misuse of Additives." Oil companies go to great trouble to find just the right additives that are compatible with their oil and will give the most benefit. For the user to add other additives without good laboratory control is a questionable procedure.

Since additives are of a chemical nature, the reactions set up by the mixture of a known chemical with an unknown one could defeat the very purpose for which the additive was intended and do more harm than good.

One question I would like to ask Mr. Clark is whether viscosity improvers have any tendency to dissipate in service, particularly automotive service.

Within the past comparatively few months, oil companies have come out with premium grade motor oil selling for around 60 cents a quart at service stations, which has very high viscosity index ratings caused by viscosity improvers. There seems to be some controversy among the oil companies, those that have it in the premium grade oil and those that do not have it, about the oxidation of viscosity improvers under automotive type use, such as heat, and so on.

M. S. Clark: Some viscosity index improvers do have a tendency to lose their potency with use; some lose it permanently and others only temporarily. Responsible oil suppliers recognize this problem and make sure their additives have good stability.

G. H. Davis: On the matter of extreme pressure agents, we must keep in mind that only certain very special compounds containing phosphorous, sulphur or chlorine can be used satisfactorily as the amount and activity of these elements must be known and controlled. One must realize that, in addition to the mating surfaces for which the lubricant is needed, it will come in contact with many other elements, such as tanks, pipes, valves and, often, entirely different metals in bearings of various kinds. In developing these very worth-while lubricants, the petroleum chemist must also bear in mind the probable maintenance procedures, such as filtering, settling or centrifuging, that the lubricant may be subjected to in service. If the oil has a weakness in this respect, the consumer will not obtain the life he is entitled to.

Another point that should be emphasized is what we call "Additive Susceptibility." It is very true that certain base oils react quite differently with various additives and, conversely, an additive will have a different effect on different oils. This is shown in Table III in Mr. Clark's paper. A great amount of time and effort has been spent by the oil companies to assure the consumer of receiving the maximum benefit from the various additives, and this should not be jeopardized by field additions or alterations.

It cannot be stressed too strongly that, for the consumer to receive all the benefits built into these modern lubricants, he must see to it that they are given every opportunity to do the job for which they are designed. By this I mean that the oils must be maintained in the best possible condition and that the systems used to dispense them be thoroughly cleaned before they are introduced.

As Mr. Clark points out, these modern additive lubricants will go a long way towards helping you increase profits, reduce maintenance and lower costs.

G. C. Almasi: One statement regarding the increased use of additives, relates directly to the increased tonnage output of our mills today, particularly of our older mills. The newer mills are designed by engineers to stand up to greater loads and higher speeds, and they do a job. Our older mills are scheduled today to put out tonnages comparable to some of the new mills, and it is largely through the use of these additive fortified lubricants that these old mills are able to survive competitively.

Specifically I have in mind rolling mills constructed 50 years ago and developed to roll 2½-ton ingots. With little material subsequent support, these mills in order to meet new economic conditions were pressed into processing 7-ton ingots, and they now regularly roll 9½-ton ingots. The use of additive fortified lubricants is adamant to essential bearing and tooth surfaces.

Joseph R. Sadowski: In using an extreme pressure lubricant having lead naphthanate as the extreme pressure additive, there seems to be one theory that the lead in the oil could precipitate out on the lead bearing.

I would like to have some comment from the speaker on that subject.

M. S. Clark: The original leaded lubricants that were made up contained lead oleate. These used to give some trouble with separation of lead compounds, but the lead naphthanate which most oil companies use now is very stable, and there is little, if any, trouble with lead deposits.

Andrew E. Cichelli: In reviewing this paper one cannot help but be impressed by the terrific job that has been done by lubrication suppliers in providing us with tailor-made products for almost any situation. However, the advent of these additives, some of them at least, has created some new problems on their own.

First, of course, is the problem of depletion of the additive in service. Then there is the problem of the effect of contamination, water and scale, and so on.

Compatibility is another serious matter, to which Mr. Whiteley so aptly referred. I believe Mr. Whiteley would rather clean the system and replace the oil. I would like to know whether the author thinks that is the only thing we can do, or has he investigated his competitors' products sufficiently to be able to say that we can mix similar products indiscriminately and safely? That would be the ideal.

Then there is the question of the mutual effect of the additives in a product on each other. The type of base stock that is used is apparently an important factor in the performance of a product; should we be concerned about combinations of additives as well?

There is another disturbing problem that has cropped up since the advent of the extreme pressure agent. That would be the tendency of equipment builders to take advantage of their availability by skimping on gear size and gear metallurgy. It is understandable to reach for an extreme pressure lubricant when we are in trouble, but it is unthinkable that gears and pinions should be designed so closely that we must start with extreme pressure lubricants to avoid wear.

Where is the margin of safety demanded by good gear design practice? I cannot help but suspect that when equipment builders specify extreme pressure lubricants to start out with, they have reduced the safety margin in their design, expecting to pick up the difference in the lubricant. Whereas at one time all equipment was designed to operate on straight oils and non-extreme pressure greases, now much of it built today would fail if special lubricants were not used to start with.

M. S. Clark: Of course, the reason for an additive in an oil is to have it available for use when needed. The rougher the service the quicker the additive will be used up. We have seen extreme pressure gear lubricants which have been in gear sets for years and have never lost their extreme pressure characteristics. In other sets, the extreme pressure properties may be depleted considerably in six months.

This is due chiefly to the severity of the service to which the oil is subjected. If the service is extremely heavy, or if there is something mechanically wrong with the equipment producing excessive heat or pressure, the additive will eventually be used up.

As far as compatibility is concerned, I believe most oil suppliers would caution against mixing two varieties together. Usually the oils themselves, if they are brand new, are compatible. Laboratory tests can be made to find out if they are compatible. Mixtures can be put in bearings and operated for a while. They can also be heated up to see if any deposit is formed, and they can be cooled down to see if there is any adverse effect at low temperatures.

We are definitely opposed to adding a fresh oil to a used oil of another variety which may be contaminated. The fresh oil may cause precipitation of oxidation products and contaminants, causing sludge formation.

It is possible that one type of additive may have an adverse effect on another. Compatibility tests can determine this.

We observed some tests on a railroad where five competitive unused greases, containing various additives and various types of soap, were blended together and used to lubricate car journal roller bearings. After several months operation on the road there was no apparent adverse effect.

As to the assertion that gear manufacturers may be skimping on the size of gears, I rather doubt if they do.

Member: Mr. Cichelli suspected that maybe some of the manufacturers might be under-designing their gears and making it up in the use of extreme pressure lubricants. Regardless of how well a gear is designed or manufactured, there will always be high spots. In spite of the fact that they may lap the gears in, they cannot get those gears in perfect mesh under the load conditions that you will experience in the mill.

You may be able to lap them in perfectly on the stands or in the shops, but when you get the loads on them you are going to have a different meshing of those gears. That is where I think the extreme pressure gear lubricants are important, regardless of the size of the gears or anything else. I think you will have to have something to wear those gears in.

Then the problem comes up that maybe we need them only when the gears are first manufactured, and then we can dispense with extreme pressure gear lubricants. As has already been brought out, the customer himself, after he gets a piece of equipment, usually overloads it and wants the gear to do much more than it was designed to do, and then he is right back to the point where he has to have the extreme pressure gear lubricants to keep the machinery running.

Andrew E. Cichelli: There have been a number of recent instances that have come to my attention that have convinced me that mill drives and pinions were short on design.

I am going to ask those who come to the defense of equipment builders to tell us how we are to lubricate this equipment ten years from now when very likely we shall be wanting to produce above present day rates. Will there be new products available to keep pace with the needs of this equipment? If a gear is designed properly and if its metallurgy is right, there is a far better chance that our present day machines can be overloaded in the future. Where AGMA standards have been adhered to, there is a good chance that enough of a safety margin has been built into the gear or pinion.

Unfortunately for the more severe steel mill applications, AGMA standards are not readily applicable—though I understand AGMA is reviewing steel mill equipment for the purpose of establishing standards for our industry. Until such standards are set, we must rely on the equipment builders to supply us with gear components sufficiently capable of the job at hand without having to resort to special lubricants for support.

If we start out with equipment that must use extreme pressure lubricants to "survive," we will have preciously little margin to work on if we ever wish to increase our production rates. I believe a critical review of this situation should be made to determine whether something cannot be done to improve this state of affairs.

Developments in Steam

By F. X. GILG
Executive Assistant
and
NORMAN W. YOUNG
Assistant Chief Staff Engineer
Boiler Division
The Babcock and Wilcox Co.
New York, N. Y.

▲ THE process of making steel creates by-product fuels. The quantity and variety exceeds that produced by any other single industry. The increasing dollar premium placed on prime fuels makes efficient utilization of by-product fuels mandatory for most steel plants. The economical use of these fuels singly and in combination has been a major factor affecting the development of steam generating equipment for steel mills.

The demand for steam in most steel mills is usually more consistent than the supply of by-product fuels. Thus, designs are further complicated by the requirement that they burn these fuels singly and in combination with the primary fuels—coal, oil and possibly natural gas.

Generally, the by-product fuels involved are blast furnace gas, coke oven gas, and coke breeze. Blast furnace gas can be burned quite easily provided proper care is taken in the design to account for the large resulting volumes of combustion gases and provided the unit is designed to take care of possible dust accumulation on the heat absorbing surfaces.

Coke oven gas is very similar to natural gas in its burning characteristics, and usually gives little trouble when burners are designed for in service cleaning to remove the tar products often present.

Coke breeze is by far the most difficult fuel to handle from a combustion standpoint, but it presents few problems in furnace or boiler cleanliness.

DEVELOPMENT OF EQUIPMENT FOR BURNING COKE BREEZE

Of the by-product fuels, coke breeze, is probably the least likely to win a popularity contest among boiler operators. Table I shows a typical analysis of this fuel. Note particularly the very low volatile content which makes ignition very difficult. To date, the most practical method of burning coke breeze has been to use a chain or traveling grate stoker.

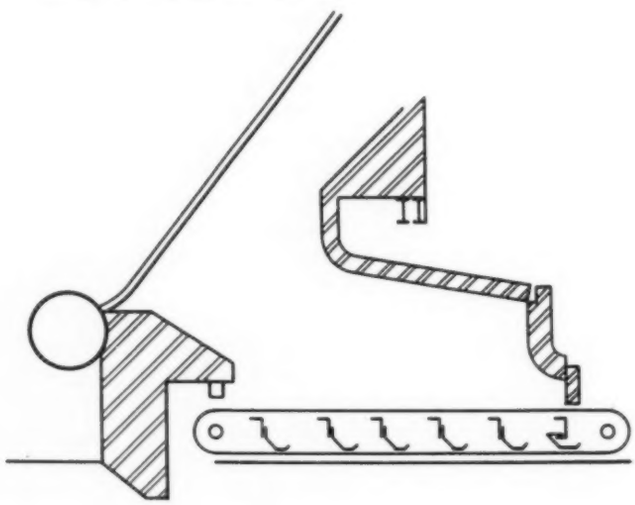
TABLE I

Typical Analysis of Coke Breeze (As Fired)

Moisture, per cent	18.9
Volatile matter, per cent	1.4
Fixed carbon, per cent	65.6
Ash, per cent	14.1
Sulphur, per cent	0.5
Btu	9610

It has long been recognized that an extremely hot combustion zone is necessary to maintain ignition of coke breeze. Early installations of coke breeze stokers utilized refractory furnaces with long front arches similar to Figure 1. This type of arch proved adequate for many plants, but the arch maintenance was excessive. The stoker burning rate was necessarily low, and it was often found desirable to aid ignition by the use of supplementary coke oven gas torches at the front of the unit.

Figure 1 — Early coke breeze stokers had refractory furnaces with long front arches.



Power stations for steel plants are complicated by requirements for using a number of by-product fuels whose supply may be erratic . . . . ingenious designs now meet this problem . . . . units are also designed for higher availabilities and minimum maintenance through use of complete water cooling, single gas pass convection, and retractable soot blowers.

Generating Units for Steel Plants

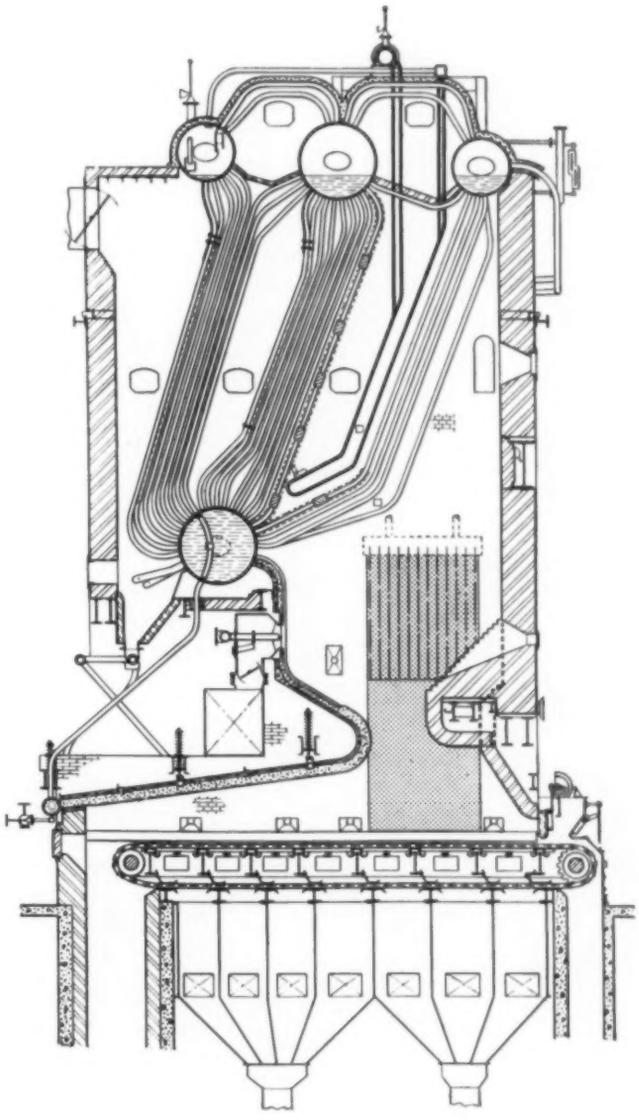
Economic pressure soon made it clear that some means of burning at higher stoker ratings would have to be developed to keep pace with increased boiler capacities and to lower arch maintenance. Figure 2 shows the type of arch developed to meet this need. With this arrangement, the method of burning differed from that of the front arch design. The front arch unit employed a long, non-turbulent fire, igniting over the first two stoker compartments (where all air was shut off), and gradually burning out at low undergrate air pressures over the rest of the stoker. The long rear arch shown in Figure 2, combined with a short front arch, requires a different method of operation. The front stoker compartment contains a "dead" plate which prevents the air from chilling the incoming fuel. The fuel is then gradually heated to ignition temperature as it travels into the furnace. Normally, no air is introduced through the second stoker compartment. In the third or fourth stoker compartment, the undergrate pressure is highest and this is sometimes called the "blast" compartment. The burning is intense in this zone. As a result of the blasting action, many of the incandescent particles are lifted off the grate, carried toward the stoker gate by the horizontal flow of gas and deposited under the front arch in the ignition zone. The radiant effect of front arch, and these burning particles are the medium by which ignition is maintained.

This arch design permitted higher stoker burning rates and for some years improvements in burning coke breeze consisted of experimenting with more favorable contours of the front and rear arches.

Figure 3 shows data pertinent to the stoker performance of a typical job of this design as compared to the performance when using a long front arch design. The compartment air pressures in Figure 3 also indicates the difference in the type of burning for the two arch constructions. Low air pressure over most of the stoker for the front arch design results in a long slow, gentle fire. High pressure over a small part of the stoker for the rear arch design is indicative of violent turbulent burning. The compartment pressures shown are of particular significance. Note that although the dampers were closed on Compartments No. 2, 3, and 6 for the rear arch arrangement, there was a positive pressure in these compartments. This was due to air leakage around the seals between adjacent compartments. Further, on this type of installation there was considerable evidence of air leakage around the gate of the stoker. The construction employed at that time made a tight seal at these points impossible.

It was some time before the real significance of inadequate air control was realized. When it finally be-

Figure 2 — This unit has a long rear arch combined with a short front arch.



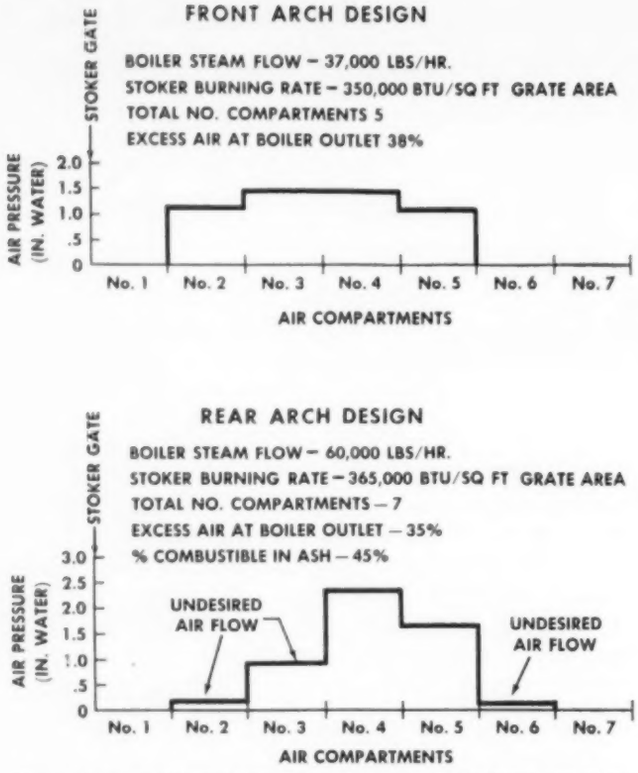


Figure 3 — Performance data of two arch designs are given by sketches.

came apparent that air leakage around the stoker gate was extremely detrimental to ignition, the arches were moved very close together to form a throat above the stoker. This throat was sized so the pressure drop across it was equal to the draft created by the furnace height, and thus a balanced pressure could be maintained over the stoker while a draft was held above the throat. This minimized leakage of air at the stoker gate and its chilling effect on the arch. Positive control of the air to each stoker compartment was also recognized as a necessity, since leakage into non-burning compartments adversely affected ignition and made overall operation extremely sensitive.

The method of burning employed with the long rear arch also showed that the sizing of coke breeze greatly affected the combustion process. The optimum sizing for coke breeze is $\frac{3}{8}$ in. to 0 in. with not more than 20 per cent through a $\frac{3}{32}$-in. round hole screen.

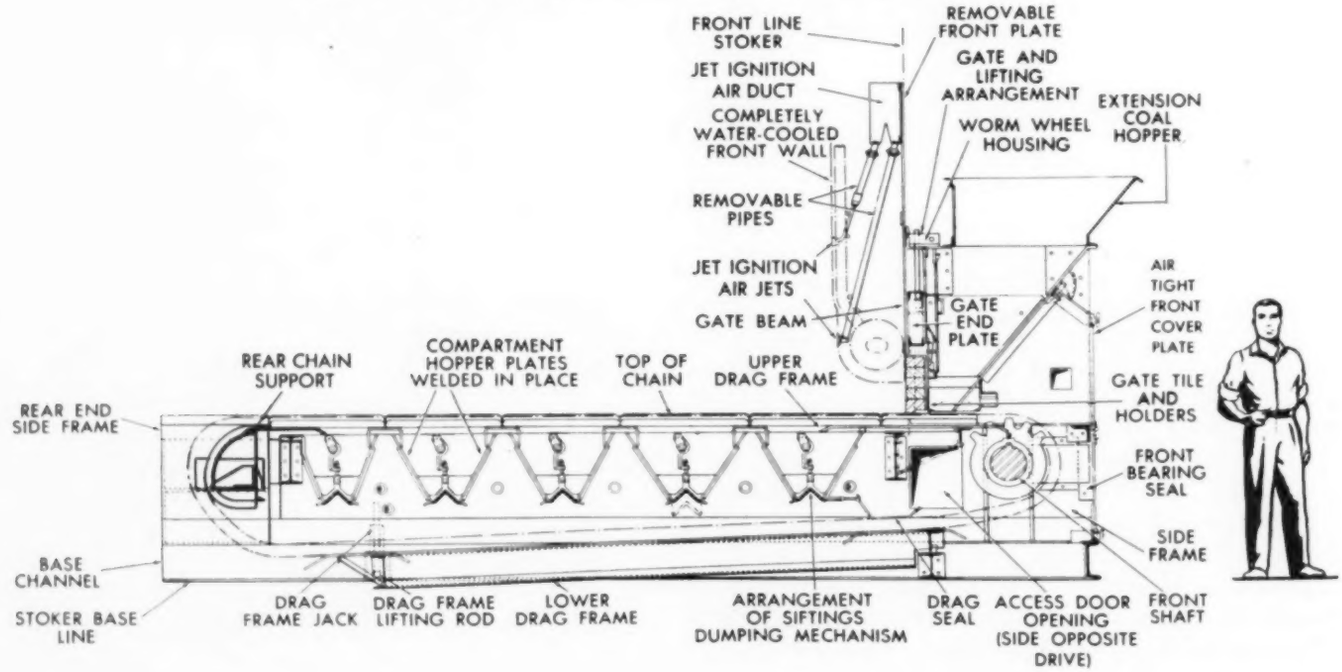
The burning of coke breeze has been further hampered by attempts to design furnaces to burn either bituminous coal or coke breeze. Due to the higher volatile content of coal, long arches are not required and are actually troublesome. Attempts to modify the furnace design to suit bituminous coal generally result in compromising the ability of the unit to burn coke breeze. The result is that neither fuel is burned well. The furnace requirements of the two fuels are simply not compatible, and the best solution to date has been to design the furnace for coke breeze and accept the resulting capacity reasonably obtainable when burning coal.

To summarize, the following factors were found to particularly affect a coke breeze application:

1. Furnace arch contours.
2. Air leakage through the stoker gate.
3. Air leakage between adjacent stoker compartments.
4. Sizing of the fuel.

The desirable contour of arches and sizing of the fuel are well established from past experience. The matter of air leakage can only be overcome by redesigning the stoker components. In 1949 the author's company set out to eliminate some of the inadequacies of the existing equipment. Figure 4 shows the results of the stoker development work. In addition to other improvements, the air zones in individual compartments were confined within hopper shaped ducts. This eliminated the drag seals formerly used and effectively eliminated leakage between stoker compartments, giving 100 per cent control of air flow. Air admission to

Figure 4 — This chain grate stoker design minimizes air leakage.



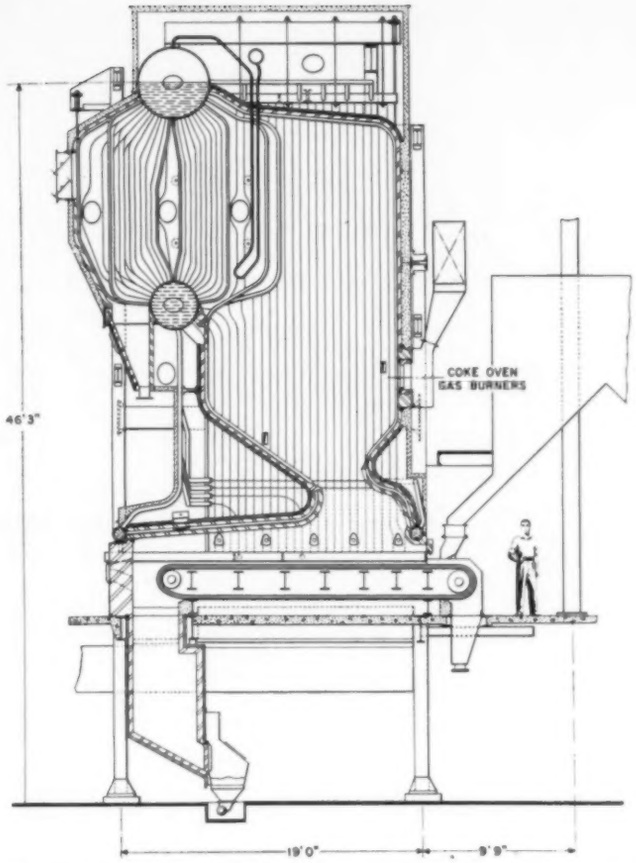


Figure 5 — This plant oiler unit was designed for capacity of 55,000 lb of steam per hr when firing coke breeze.

compartments is controlled by poppet type valves which are completely air tight and have excellent control characteristics. Siftings fall into the air compartment where they are periodically dumped to the lower chain strand and carried forward to a siftings disposal hopper. The front of this stoker has been completely sealed and air leakage under the gate eliminated.

Figure 5 shows the layout of a job using the improved stoker features. The unit is designed for a capacity of 55,000 lb of steam per hr when firing coke breeze. It is equipped with annular type coke oven gas burners, to produce 60,000 lb of steam per hr when firing both fuels in combination. The design pressure is 200 psig and operation is at 175 psig with 365 F total steam temperature. The boiler is of the single pass, low draft loss design. In Figure 6 the stoker performance data is compared with that of a job without these features.

The improved features have resulted in good control over ignition and operating flexibility. High stoker firing rates are easily maintained and the unit has shown none of the difficulties formerly associated with coke breeze installations. Bituminous coal has been burned at capacities up to 60,000 lb of steam per hr and coke breeze has been burned to a capacity of 68,000 lb of steam per hr.

EQUIPMENT FOR BLAST FURNACE GAS, COKE OVEN GAS, PULVERIZED FUEL AND OIL

Advances in any field are usually the result of overcoming past difficulties. The development of the steel plant boiler as known today is the result of accumulated knowledge gained from field experience. Figure

	FORMER DESIGN	IMPROVED DESIGN
BOILER CAPACITY LBS/HR	60,000	55,000
STOKER SIZE	12'-6" W X 20'-3" L	13'-6" W X 15'-0" L
STOKER BURNING RATE	365,000 BTU/SQ FT	375,000 BTU/SQ FT
EXCESS AIR AT BOILER OUTLET	35%	35%
COMBUSTIBLE IN ASH	45%	25%

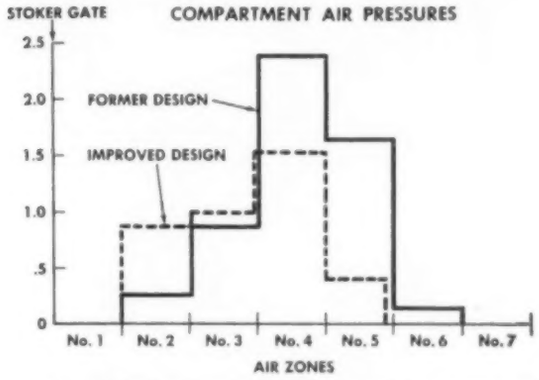
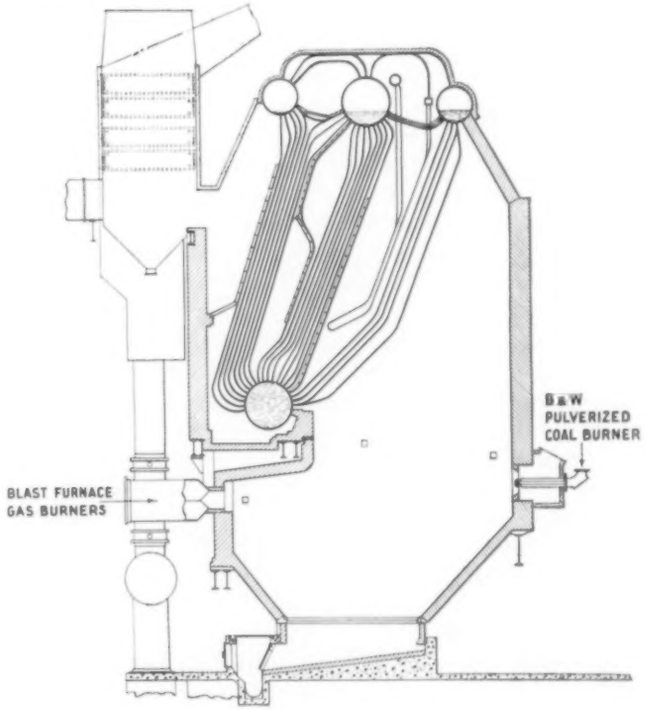


Figure 6 — Performance data of boiler is given with improved and original design.

7 shows a steel plant boiler installed in 1941. The capacity is 100,000 lb of steam per hr with blast furnace gas firing and 38,000 lb per hr when firing coal. It has a design pressure of 250 psig and operates at 230 psig with a steam temperature of 550 F. The unit is installed with an economizer and has an overall efficiency of 75 per cent. The furnace is completely refractory, and the boiler is of the three-pass design. The blast furnace gas burners are of the intertube type.

The problem of manufacturing steel economically and keeping costs down soon revealed that more efficient units having less maintenance and higher availability were required. Figure 8 shows a unit having water-cooled walls which helps to reduce refractory maintenance. This unit has a capacity of 400,000 lb of

Figure 7 — This boiler unit was designed to burn blast furnace gas and coal.



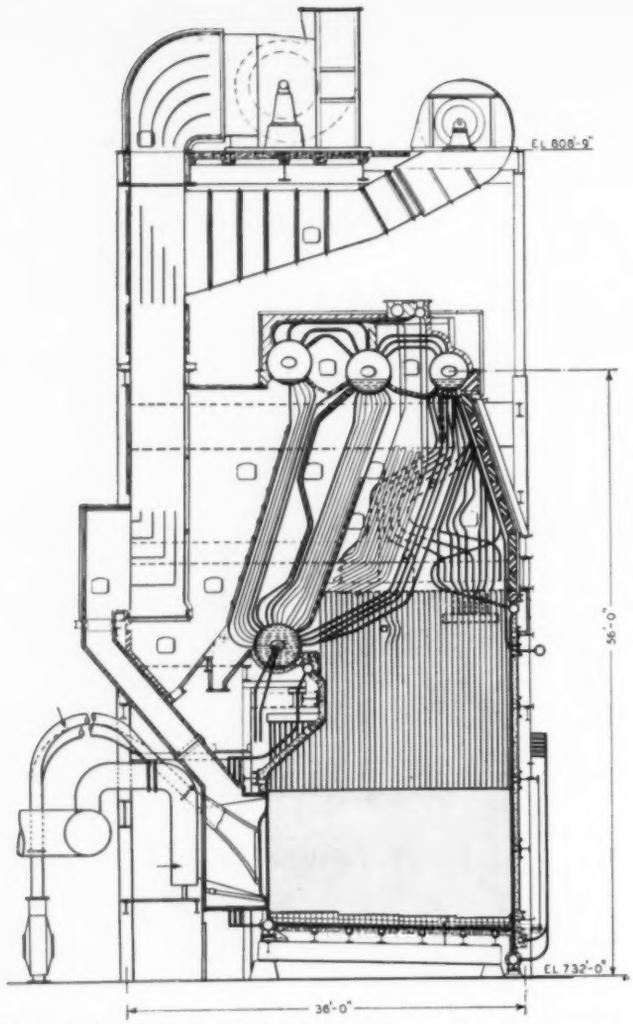


Figure 8 — The water-cooled walls in this unit reduce refractory maintenance.

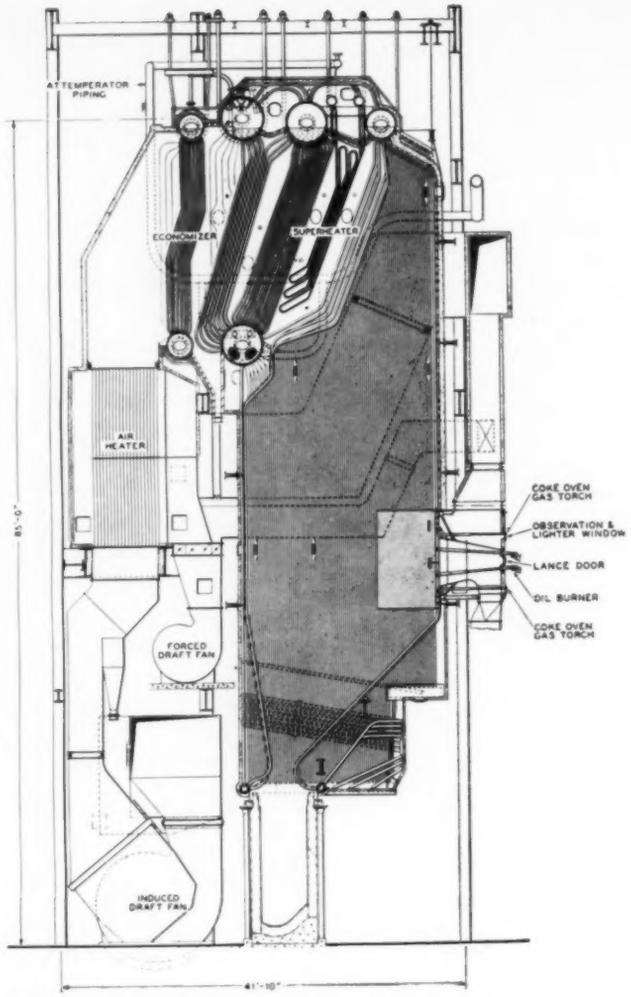


Figure 9 — Design of this unit minimizes draft loss and thus reduces fan power requirements.

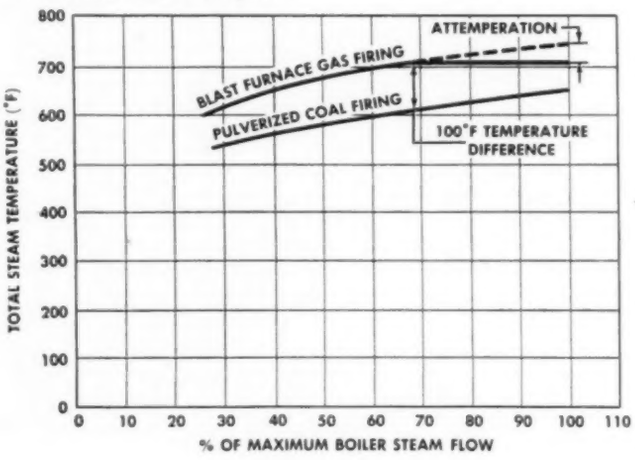
steam per hr. It is designed for 900 psig and operates at 850 psig with a steam temperature of 800 F. It is fired by blast furnace gas, pulverized coal and coke oven gas. The unit serves a topping turbine which generates power. Process steam is taken from this turbine at a lower pressure. The efficiency of the unit on blast furnace gas is about 77 per cent.

The firing of blast furnace gas results in combustion gas quantities which are about double that for pulverized coal firing for the same steam output. This means that gas flow areas must be greater to avoid excessive draft loss. When coal and blast furnace gas are fired in the same unit, a compromise is usually affected. The draft loss, when firing gas, is set as high as economics and a reasonable induced draft fan size will permit. This usually results in a draft loss on coal below that which would normally be desirable. The fans for the unit shown in Figure 8 are very large. They have a net static pressure of about 17 in. of water and require a drive turbine of 900 hp. Units of this general type perform well, but are lacking in many desirable operating features. Fan horsepower is high due in part to the high draft loss of the three-pass boiler. The three gas passes also complicate the gas side cleaning problems.

A significant development which improves cleanability and lowers draft loss and fan power is illustrated by Figure 9. This unit has a capacity of 350,000 lb of steam per hr when firing blast furnace gas. Oil burners installed for a capacity of 150,000 lb per hr. The unit is designed for future pulverized coal. The design pressure is 500 psig and the unit operates at 405 psig and 715 F steam temperature. The unit has an overall efficiency of 76 per cent.

This boiler is of the single pass design, which keeps draft loss at a minimum. Absorption efficiency is maintained by using a bank of fairly close-spaced small

Figure 10 — Convection heat transfer is higher when burning blast furnace gas.



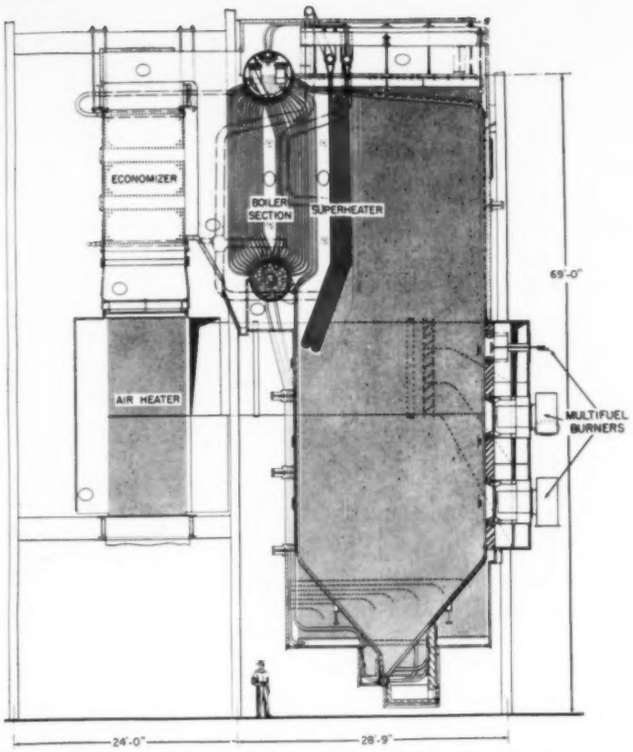


Figure 11 — Design shown illustrates latest trend in such units.

diameter tubes just behind the superheater. The net draft of the induced draft fan on this unit is 6.0 in. of water as compared to 17.0 in. for the unit shown in Figure 8.

To obtain the best possible cleaning, retractable soot blowers were used throughout the unit. The elimination of baffles and the use of vertical convection surface combined with the effectiveness of these blowers results in the cleanest gas surfaces that have been attained to date.

There are two other significant features in this unit. First, there is a patch of refractory on the sidewalls adjacent to the burners, which are of the intertube type. This was used to help promote ignition stability and to shorten the length required for flame travel. Second, this unit is equipped with a heat-exchanger type of steam attemperator located in the lower drum, a rather unusual feature for a superheater having a steam temperature of only 715 F.

Since the combustion gas weight when burning blast furnace gas is about double that for coal firing, the convection heat transfer is higher when burning blast furnace gas. The difference is substantial, and is illustrated by the curves shown in Figure 10. If it is desired to minimize this difference, sufficient surface must be installed to give the correct superheat for oil or coal. The higher steam temperature resulting when blast furnace gas is burned can then be controlled by an attemperator as it is in this case. Central station practice also has shown that if burners are located in multiple horizontal rows, some distance apart vertically, it is possible to operate the burners closest to the superheater when firing oil or coal, and thus help to minimize the superheater temperature difference.

Figure 11 shows a unit now being built, which employs many of the desirable features learned from past experience to minimize earlier inadequacies. The unit has a capacity of 250,000 lb of steam per hr when firing either oil or blast furnace gas. The design pressure is 750 psig and it will operate at 675 psig with 840 F when firing oil. The efficiency of the unit on blast furnace gas is 85 per cent.

Note that the burners are arranged in three rows. The lower two rows are combination blast furnace gas and oil burners. The top row is only for oil firing. This arrangement was used to help minimize the difference in steam temperature which would normally exist be-

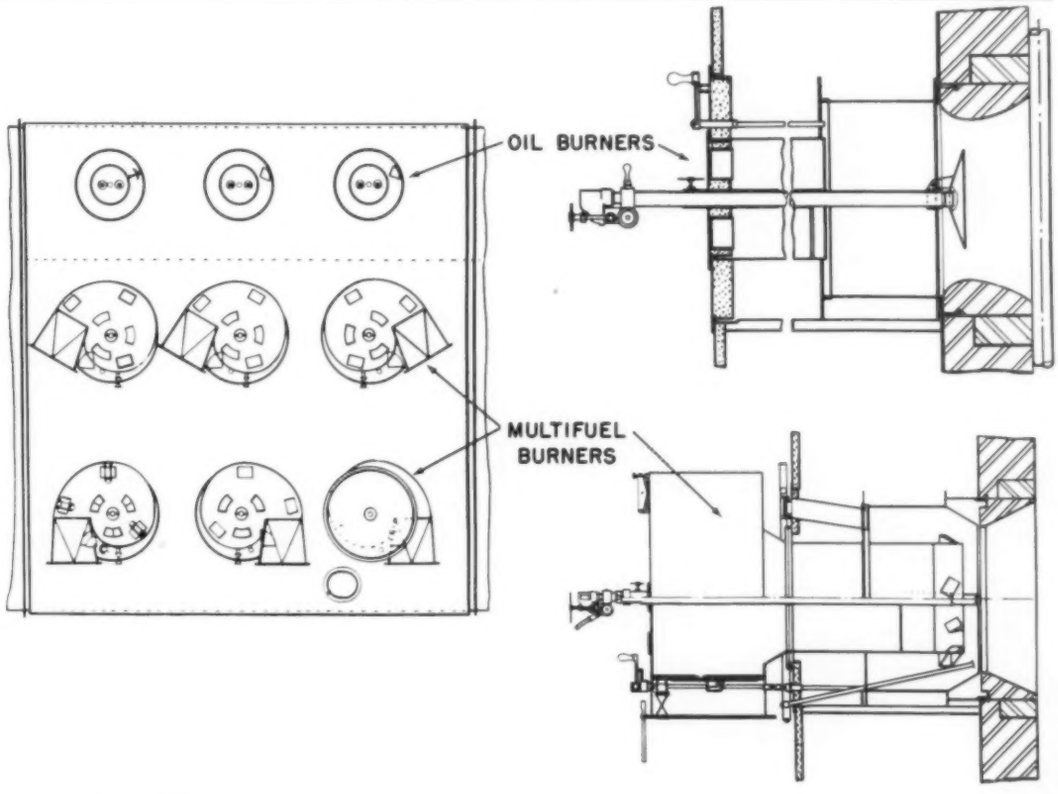


Figure 12 — Furance has oil burners and multifuel burners.

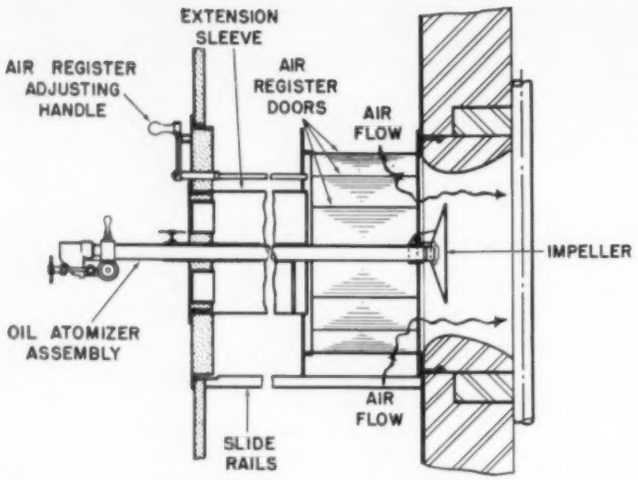


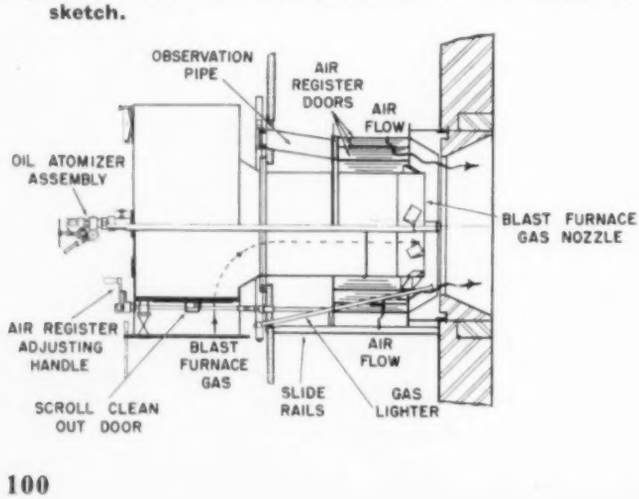
Figure 13 — Details of oil burner are shown by sketch.

tween the two fuels. It is anticipated that the upper two rows of burners will be used when firing oil alone, thus decreasing the furnace heat absorption and making more heat available to the superheater.

Figure 12 shows a detail of the burner arrangement and Figure 13 is a further detail of the oil burner. Figure 14 shows details of the combination blast furnace gas and oil burners. Note that the gas burner is of the circular type. Gas is introduced in a scroll which imparts a whirling motion to the fuel. Air is introduced through an annular register and mixing takes place in the burner throat. The resulting flame is relatively short and turbulent and extremely stable. The furnace shown in Figure 11 consists of tangential tube water cooling. There is no refractory on the walls in the burner area. The development of the circular burner has improved combustion to the point where no external aid is needed to support combustion.

The unit shown in Figure 11 has another unique feature. There is no water tube screen in front of the superheater. A superheater of the radiant type has the characteristic of a rising steam temperature as load decreases while convection absorption, on the other hand, results in a decreasing steam temperature with load decrease. Theoretically, if it were possible to properly combine radiant and convection characteristics, it would be possible to obtain a superheater in which steam temperature would not change with load. The arrangement shown in Figure 11 is intended to lessen

Figure 14 — Details of multifuel burner are shown by sketch.



the steam temperature variation with load and at the same time, decrease the difference in temperature experienced between oil and blast furnace gas firing. Figure 15 shows the superheater characteristic obtained with this type of superheater in combination with burner elevation control. For comparison, the superheater characteristic for the convection type superheater used in the unit of Figure 9 is shown. The material gain in decreasing steam temperature variations when using different fuels is quite apparent. The radiant type superheater also has a much smaller variation in temperature as load changes.

The features of this unit incorporate many of the developments in steam generating units for steel mills. Units of this type will have higher availabilities because:

1. The use of complete water cooling in the furnace eliminates refractory maintenance.
2. The use of single gas pass convection surface and retractable soot blowers eliminates the necessity of removing the unit from the line for cleaning.
3. The lower draft loss reduces the duty of the induced draft fan.

The overall net efficiency will be higher because:

1. The heat absorbing surfaces are cleaner.
2. The auxiliary power for the induced draft fan is decreased.
3. Less variation in steam temperature will permit plant equipment to operate at optimum efficiency.

The design of the unit represents the best of the hard earned improvements made during the past 15 years. These improvements are the result of work at steel as well as at plants of boiler manufacturers. By continuing to work together in the future, as in the past, further significant advances will be accomplished.

DISCUSSION

PRESENTED BY

P. H. OHMER, General Supervisor Power & Fuel, United States Steel Corp., Youngstown, Ohio.

NORMAN W. YOUNG, Assistant Chief Staff Engineer, Boiler Division, The Babcock and Wilcox Co., New York, N. Y.

HARRY I. RIEGEL, Superintendent of Utilities, Iron and Steel Division, Kaiser Steel Corp., Fontana, Calif.

JOHN J. ALEXANDER, Superintendent Electric Power and Steam, Republic Steel Corp., Cleveland, Ohio.

W. P. GAVIT, Consulting Engineer, United Engineers and Constructors, Inc., Philadelphia, Pa.

P. H. Ohmer: Current design of the boiler furnace favors the long rear arch. The proper control of air flow from each compartment is the companion requirement for burning part of the coke breeze in suspension with the air above the grate and directing the burning particles toward the front of the grate as an ignition aid. Additionally, the importance of proper sizing and dryness of the coke breeze cannot be overemphasized.

Turning to another steelworks fuel, blast furnace gas, and to the supplementary fuels that are often

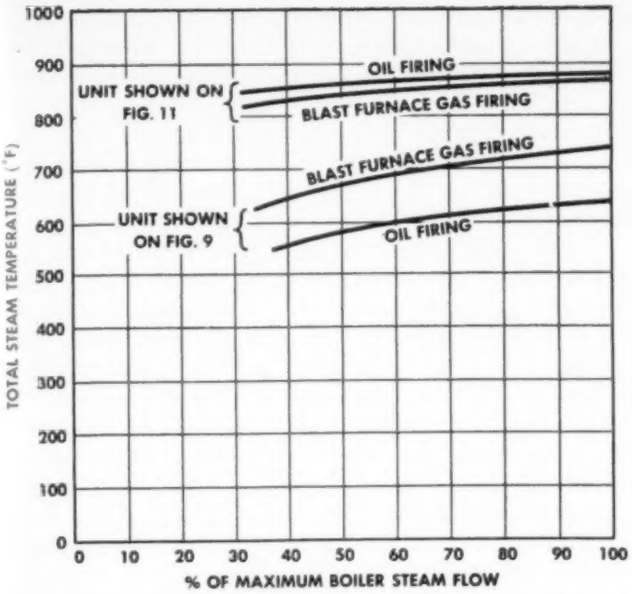


Figure 15 — Design minimizes steam temperature variations when burning different fuels.

burned either as alternates or in combination with it, the use of the attemperator or its functional equivalent for correcting steam temperature to specified steam temperature is well known. However, Mr. Young's description of the design principle of locating the burners for higher heating value in closer proximity to the superheater is instructive. Moreover, the practical application of this principle in combination with a radiant superheater, tending to stabilize steam temperature both with changes in load as well as changes in fuels, is very interesting.

Have you burned coke breeze in the cyclone furnace?

Norman W. Young: We have done some study work with low volatile fuels in the cyclone furnace. Coke breeze has not been tried on a commercial basis. The successful operation of any fuel in the cyclone furnace depends on ash temperature and slag viscosity within the cyclone proper. I am sure that eventually we will make more progress with coke breeze in the cyclone.

Harry I. Riegel: Presently, I do not have to work with coke breeze burning equipment, but I do not believe I will ever forget the headaches I had when it was my duty to adjust instruments and automatic control on a chain grate stoker burning coke breeze with poorly designed arches; leaky wind boxes; excellent segregation of fuel with the coarse on the outside and the fines in the center; and with a fluctuating steam load. It is indeed gratifying to know that these improvements mentioned by Messrs. Gilg and Young have been made.

The design of fuel burning equipment for multi-fuel installations invariably results in compromises which result in lower overall efficiency on one of the fuels. We have experienced such a condition with our older boilers where the blast furnace gas burners were designed for high load and would not operate effectively on low loads without a heavy coke gas pilot. By the installation of refractory material over water tubes in the furnace walls, the condition was partially corrected to give a relatively stable flame with a minimum coke gas pilot. However, due to intertube design of the blast furnace gas burner, it is not possible to get good mixing of fuel and air on coke oven gas or oil. The result has been a compromise between long flame and excess air. Our newer installation uses four circular type burners which seem to give us better mixing of fuel with air on all fuels and better overall efficiency. The coke gas pilot is now a safety factor and not a necessity.

John J. Alexander: Most steam plant operators will agree with the statement "that demand for steam in most steel mills is usually more consistent than the supply of by-product fuels." Mr. Young described several installations normally fired with blast furnace gas and having pulverized coal burners for use when blast furnace gas was less than fuel required for steam demand; however, the combination fuel burner has some faults that should be recognized for correction:

1. When blast furnace gas supply is inadequate, and valve to gas burner is closed, unburnt coal dust (from the coal burner) settles in the blast furnace gas burner since this is the point of lowest pressure in the furnace. If permitted to accumulate, coal dust will burn and cause distortion of the gas burner. To avoid this recirculation of coal dust, we have found it necessary to purge the gas burner, open a cleanout door, so that air flow from the room to the furnace prevents accumulation of coal dust.

2. Auxiliary fuel, coal or fuel oil, should be arranged for wide range control. Even on large boilers producing 240,000 lb per hr of steam with 4,000,000 cfhr of blast furnace gas, it should be possible to safely and economically burn coal at approximately ½ ton per hour rate to satisfy the fuel deficiency in by-product fuel. Auxiliary fuel equipment should be designed and installed to perform satisfactorily when a single unit is used to provide fuel for ten per cent of the rated capacity of the boiler.

3. I agree with Mr. Young's statements regarding advantages of lower draft loss, less maintenance and cleanliness of the gas side of single pass furnace. I am not as optimistic about effectiveness of retractable soot blowers when dirty blast furnace gas is burned. Soot blowers are effective for coal firing; however, when gas dust content exceeds 0.020 gr per cu ft due to malpractices such as lack of water to washers, or lack of power or water to a precipitator, we find it necessary to use lances on boilers of the single pass design. We have not reached the optimum design for either blast furnace gas cleaning equipment or flue dust removal from the surface of steam generating units.

4. Mr. Young indicated that the circular burner has improved combustion to the point that no external aid is needed to support combustion. I agree with this conclusion; however, I am a strong advocate of the use of a small pilot burner due to lack of reliability of blast furnace gas and necessity for abrupt, changes in fuels to the burner. Our supply of blast furnace gas can remain fairly stable for several weeks and abruptly decline, so that coal firing at the rate of 20 tons per hr must be in service in thirty seconds. Pilot burners permit rapid changes in fuels with less hazard.

I would like to ask Mr. Young whether use of auxiliary fuel burners at a higher elevation in the furnace for steam temperature control, reduces the efficiency

of the boiler compared to use of the burners at normal furnace elevation?

Norman W. Young: Mr. Alexander, I do not think I can take exception to anything you have said. Your mention of settling out pulverized coal in a circular blast furnace gas burner when the gas element is shut down is definitely a valid observation. We have had that difficulty. We developed a more permanent cure than opening observation doors. We use air scoops at the tip end of the burner which sweep the forward part of the blast furnace gas tip and effectively keep it clear of dust. This is now a standard construction on the circular blast furnace gas burner. It is a very simple thing. It is just an air scoop which keeps the area clear.

Your requirement to fire prime fuels, presumably pulverized coal, down to loads of half a ton per hour or 10 per cent of rate of boiler load, is certainly a very desirable thing. We realize that blast furnace gas is not always available nor can you tell when it will not be available. We do have some problems in designing pulverizers and burners to take care of a ten-to-one load range. If you consider that the air pressure drop through a burner varies directly as the square of the air quantity flowing through it, you can see that the pressure drop at 10 per cent load is 1/100 of that at full load. If your burner resistance at full load is two in. of water, it is 0.02 in. of water at one-tenth load and you can see some of the problems involved there.

There are many operators who have installed low load burners to take care of just the conditions that you mention. However, there are still some problems involved.

I did not mean to imply that the soot blower has solved all cleaning problems. There are many answers that all of us are still hunting for. This soot blower has thus far proven to be the most effective means of cleaning. Experiments now being performed here and in Europe have indicated that possibly a new method of cleaning, called gravity shot cleaning, may eventually prove a better solution than these soot blowers. We do not know yet.

The use of a pilot for blast furnace gas firing has been the subject of many discussions. There are many people who will agree that this is the proper way to do the job. We are always somewhat hesitant about pilots because it gives the operator confidence that may perhaps encourage him to get a little bit careless with his burner operation. That carelessness even though unintentional, may occur just at the time when the pilot has gone out. This is why we like to approach the pilot question with caution. We will work with anybody who prefers their use.

You asked if the location of the burners high in the furnace would lower efficiency. There is no doubt that it does increase the exit gas temperature from the boiler because the furnace cooling is not fully effective. However, in most cases this decrease in efficiency is less than that which would be experienced by the decreased steam temperature resulting when the burner is located low in the furnace. That is, the lowering of steam temperature adversely affects the efficiency of the equipment you are operating, not the boiler efficiency.

W. P. Gavit: It is interesting to note that we installed about 1928, three units with the opposed burner arrangement, blast furnace gas on one side and pulverized coal on the other, shown in the author's Figure 7. The boilers were rated as 2000 hp and produced about 110,000 lb per hr on blast furnace gas alone and about 160,000 lb per hr on gas and coal in combination. Tests showed average efficiency of 73.1 per cent on blast furnace gas and 76.8 per cent on the combined fuels. Air preheaters of the plate type were installed which gave air temperature to the burners at 600 F.

The bin system was used for pulverized fuel and the fuel control was completely automatic. When blast furnace gas supply valves were fully open and there was still demand for more steam, the pulverized coal system started up. This plant gave completely satisfactory operation for many years; in fact, we have no information to indicate that it is not still in operation. While the bin system for pulverized fuel firing is hazardous and liable to explosions, it is the best purely from the standpoint of automatic operation. This plant operated day in and day out, the coal coming on and shutting off as the load and gas availability required. However, we would not care to have you go away with the impression that we favor the use of the bin system. For all its operating advantages we believe it is too hazardous. Systems using direct-fired pulverizers are commonly used today and while not as quickly responsive to automatic control have proved generally satisfactory in operation.

The authors have made no mention of the combination firing of blast furnace gas with coke breeze. Attempts have been made to pulverize coke breeze and burn it in the same way as pulverized coal. This has never been practically successful due to the highly abrasive character of the material.

A number of installations have been made in which coke breeze is burned on a traveling grate and blast furnace gas is fired in the furnace above. There is the problem of protecting the grate in case there should be no coke breeze but this seems to have been handled with reasonable success. It would seem to be an arrangement to be avoided if at all possible. In most of our steel plants that contain blast furnaces, there is sufficient coke breeze available to warrant installation of a boiler or boilers to consume it. The traveling grate does not lend itself for use as an auxiliary fuel burner to come on and off as the exigencies of the blast furnace gas supply demand. However, this combination firing system is interesting as a step in the development of steam generators for steel plants.

The authors do not mention the use of preheated air or gas. The combustion characteristics of blast furnace gas are greatly improved with heated air. We have also found it of definite advantage to use a moderate preheat with coke breeze on traveling grates.

The question of furnace volume for blast furnace gas is important because of the low combustible content of the fuel. Our practice has been to keep the heat release per cu ft below 20,000 Btu. Some remarks on this point would be interesting.

Norman W. Young: Mr. Gavit mentions a heat release of under 20,000 Btu per cu ft of furnace volume when burning blast furnace gas. In general, we are in agreement but, in any specific case, the size of the furnace would be dependent upon several factors including the type of burners and gas being burned, and whether preheated air is available for combustion.

By
A. B. MILLMAN
Assistant Superintendent of Maintenance
Jones & Laughlin Steel Corp.
Aliquippa, Pa.

The story of the electrification of J&L's blooming mill at Aliquippa is a saga of a tough job, well done, on time.

Figure 1 — The mill with the steam drive held world records for small ingots for many years.

Modernization of 44-In. Blooming Mill at J&L's Aliquippa Works

▲ THE electrification of this mill offered the electrical industry a challenge and some difficult problems in producing a unit which would equal or surpass the enviable record of the steam engine. This mill, driven by a 44 x 70 x 60-in. twin tandem-compound engine with steam at 150 psi held the world's record for small ingots for many years. It could accelerate or reverse, without steel in the mill, at the rate of 98 rpm per second.

The steam engine, over a period of years, at different times, had developed cracks in the cast iron bed plate sections which necessitated the installation of slab patches, dowel bolted and welded. As this engine had given 41 years of service under extreme high production levels for a steam engine, concern was felt that at some time, the possibility of a major wreck would put this mill out of production for a considerable length of time. As the risk of this potential loss of production to the entire Aliquippa Works was anticipated, electrification was therefore resolved both for the previous reason and also for reasons of economy.

We at Aliquippa were also confronted with a challenge which was to complete this job with a minimum loss of production during the preliminary construction period, and that phase is what will be discussed here. The problems brought up by the preliminary work were overcome without any loss of production on the mill, and the actual conversion was made in the record time of 7 days, 14½ hours.

First, before actual construction began, the engineering, construction, maintenance and operating departments were co-ordinated together so that any part of the work could be resolved without loss of production.

The original engine room not only housed the steam engine, but also the hydraulic pumps, accumulator, and roll balance accumulator. This hydraulic system not only serviced the blooming mill, but also the converting mill and open hearth department.

Two 2000-gpm centrifugal pumps were driven by topping turbines with steam at 410 psi and exhausting into the low pressure receiver to the engine at 150 psi. This steam was desuperheated and enabled us to maintain steam temperature at 400 F at the engine.

Also two low pressure cross-compound reciprocating pumping engines were in this system which were to be scrapped.

Preliminary construction work before conversion consisted of the relocation of the hydraulic equipment, the installation of an individual roll balance system for the mill, and the relocation of the hydraulic oil system servicing the pilot valves and jacks for the operation of the hydraulic manipulators.

To make room for the added equipment necessary for the electrification, it was necessary to add a 16½-ft section to the length of the engine room building, and also a 20 ft addition to the width of the building which

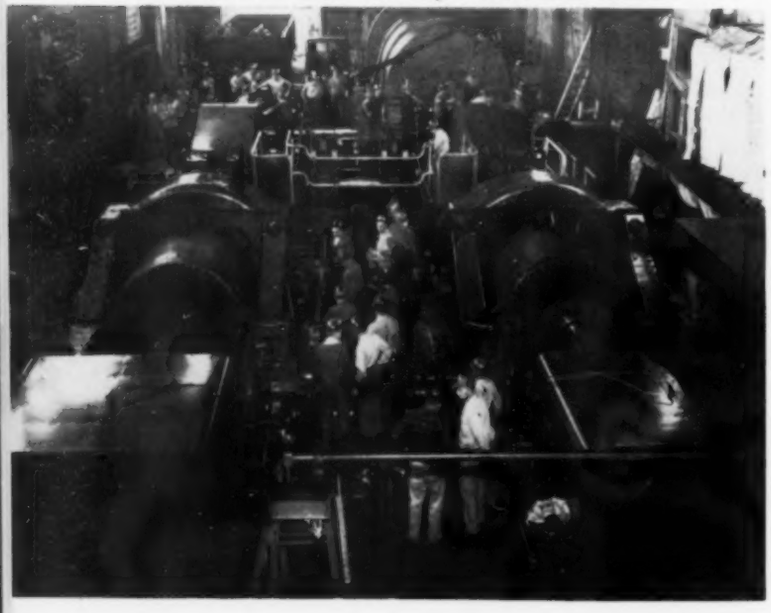
Figure 2 — The underground power distribution system for the bloomer was installed about a year prior to the changeover.

made the new motor room 191 ft-6 in. x 68 ft-6 in. The 20-ft extension is on three levels—basement, operating floor level and balcony.

In addition, a new 50-ton electric crane was installed in the mill building. Also a 30-in. concrete reinforced sewer was tunneled under the mill tables which serviced the hydraulic and electric shears during mill operations.

A 69-kv power line was built approximately 1½ miles long to the substation at our 14-in. mill, and from there continuing as an underground power distribution system to and through, the hot bed area and thence to the blooming mill motor room proper.

Figure 3 — The men are shown waiting for the last ingot to pass through the mill — September 8, 1953.



It was also necessary to relocate the complete water supply system to the new hydraulics building, and also to furnish water for the air coolers and air washer for the motor room.

Before field construction was started, all craft foremen were called in and briefed as to their responsibilities to bring this job to a successful completion. Regular weekly meetings were set up which included all general crafts foremen, construction, engineering, and operating personnel. These meetings were designed to lay out the work and to set completion dates for the various phases of the work. In this respect each man was alerted to his responsibilities to see that his particular part of the job was completed as per schedule.

Actual construction began May 28, 1952 after blooming mill millwright shop and personnel had been temporarily relocated. The excavation for the new millwright building, pump house, and 20-ft extension proceeded on schedule.

As the hydraulic system, after conversion, was to be powered by low pressure turbines, it was necessary to install a dual piping system consisting of high and low pressure piping to maintain engine efficiency. It was also necessary to relocate the high pressure turbines to maintain efficiency on the steam engine.

A new 22-in. roll balance accumulator was installed on the riverside of the mill which made it possible to discard the two 12-in. accumulators which at the time were servicing the old mill.

The engine room building was of the high and low bay type construction with louvres on the high bay for ventilation. As the new building was to be pressurized, a new roof of the butterfly type was designed and to make possible the installation of this new roof, it was necessary to build a sub-roof using the bottom cords of the roof trusses as supports.

The 20-ft extension after completion permitted the brick wall of the original building and all equipment formerly carried on this wall to be dismantled. The balcony of the new building houses the main exciter sets, the adjustable voltage control, auxiliary motor-

Figure 4 — The northwest corner bedplate is being hitched up for removal — September 8, 1953.

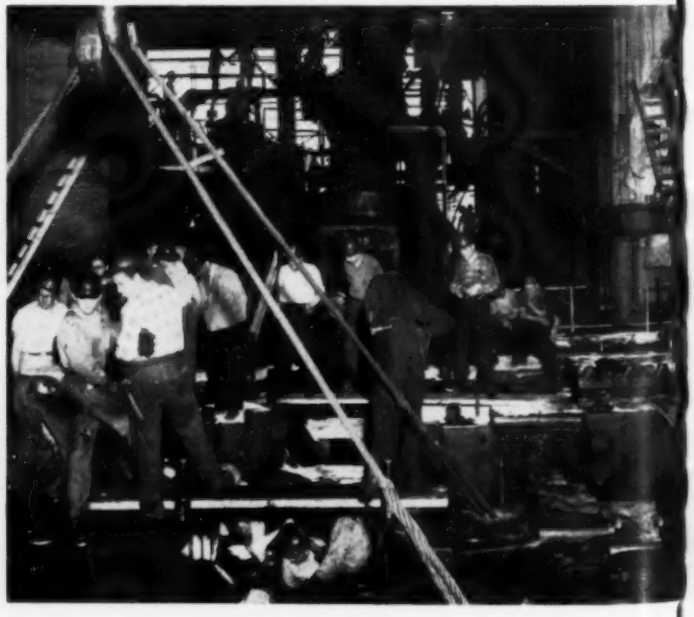


Figure 5 — Men are drilling and chipping on the concrete foundations — September 9, 1953.

Figure 6 — Shims are being set for the mill shoes and bottom bearing halves of lower motors are being cleaned — September 11, 1953.

generator sets, the rotating regulator sets, and the 250-volt battery. The operating floor houses the substation, switch gear, slip regulator, etc. To protect this equipment a partition of corrugated sheeting was installed in place of the brick wall which was formerly the outside wall of the engine room.

Excavation of the north end of the engine room was a considerable problem as huge concrete foundations of the reciprocating hydraulic pumps, accumulators, and turbine pumps created a serious dust hazard to the operation of the engine. To combat this, a barricade was constructed as close to the engine as possible, sectionalized to permit removal for engine maintenance as required.

Certain columns in this portion of the engine room had to be shored up, pile driven, and new piers poured. Piling for the main motor generator set was driven 89 ft to bedrock.

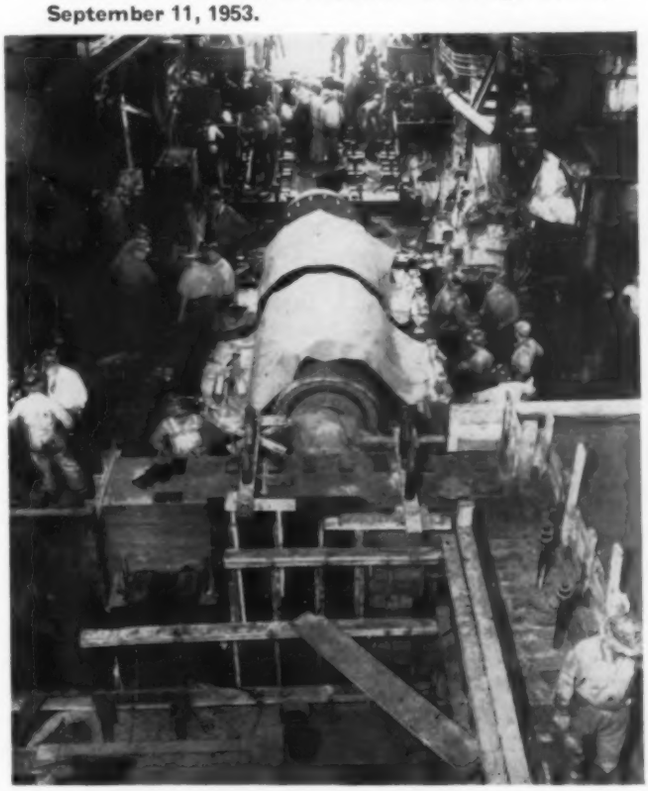
The main motor-generator set is 6-unit, 7-bearing, 360 rpm set. Each of the four generators are rated at 3000 kw. The flywheel of this generator set weighs 111 tons, and is of fabricated construction. This set is driven by a 9000-hp, 6600-volt, 3-phase, 60-cycle induction motor.

Previous to this construction period, due to the condition of the old mill housings, it was decided to purchase a new mill, and this was done in 1948. This mill was placed in storage, and during this construction period was taken out of storage. A temporary foundation was built outside of the mill building and this mill was then completely assembled to assure its immediate operation when installed.

To speed up the conversion time, it was decided to take out only that portion of the engine which would permit necessary clearance for the installation of the main mill motors. A cut-line was established on the engine which required burning through cored cast iron sections up to 14 in. in thickness.

Tentative schedules were set up in January, 1953, and the complete job was broken into two parts: first, the dismantling of the steam engine and the installa-

Figure 7 — Upper motor bed form work has been partially removed to permit installation of bridge beams — September 11, 1953.



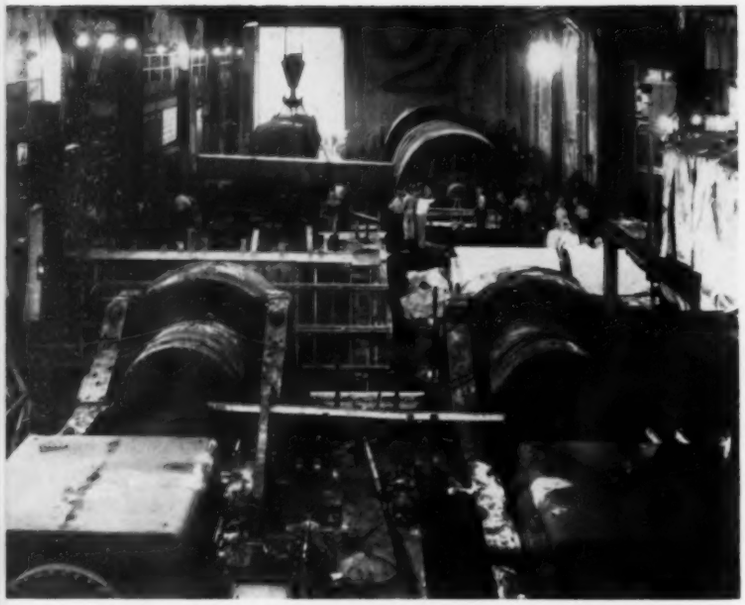


Figure 8 — Upper motor bridge beam assembly is being installed — September 11, 1953.

Figure 9 — Rotor for upper motors is being put in place — September 12, 1953.

tion of the new 12,000-hp motor drive; and second, dismantling of the old mill and the installation of the new mill.

At the regular meetings these schedules were carefully gone over in detail with the various crafts to formulate the ultimate master schedule for a minimum of down time.

It was also decided to incorporate the rehabilitation of the entry and delivery mill tables in the mill schedule.

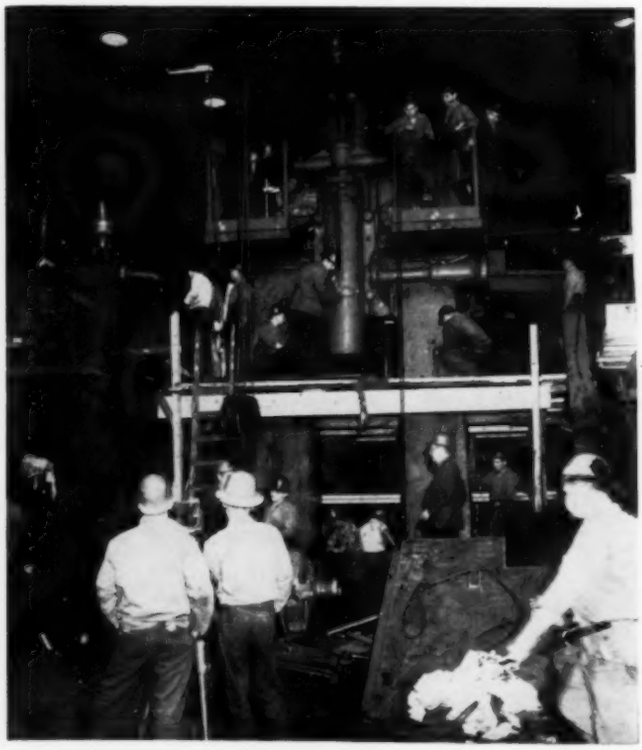
When the master schedules were completed, they showed in complete detail every phase of the work, the responsibility of the individual for the performance of his work, also showing crane priority for the various crafts at all times. It was decided to work three turns of 8½-hr shifts so that shifts could be changed on the job without any lost time involved.

As the manpower of some of the crafts was not adequate, it had to be augmented from various other departments in the plant. Each foreman was then requested to submit his manpower lists, showing names and check numbers, and the supervision for each turn. These were carefully gone over, and when approved were printed, and each foreman was given a list showing each man and supervisor who was working on his particular turn.

After the supervisors were entirely familiar with the

Figure 10 — New mill housings are being raised — September 12, 1953.

Figure 11 — Mill assembly is underway — September 13, 1953.



schedules as set up, they were given copies of the schedules and instructed to hold regular meetings with their men to familiarize them as to their part in the conversion and submit reports of same to the supervisor of construction.

Mass meetings were also held with the various maintenance crafts and operating crafts to thoroughly familiarize all with the schedule. It was strictly pointed out that under no circumstances would there be any deviation from the master schedule as shown. It was interesting to note that as conversion day came closer, some of the most skeptical persons who had previously scoffed at the idea of this quick conversion, actually remarked that they thought this schedule could and would be beaten.

Another schedule was made up in which he had asked management for a three weeks notice before the actual mill shut down. This schedule consisted of numerous items which it was felt could not be safely done too long before the conversion.

Through-holes were drilled at this time through bed plate sections at various points after careful analysis had been made as to the proper points to place hitches. Hitches were also attached. Pockets were chipped at various points in the engine foundation, and 500-ton jacks placed to facilitate removal of engine sections if necessary.

Also 22 cu yd of concrete was removed by tunneling under the engine while in operation, which later served to make removal of the rest of the concrete easier.

All materials stored at various points in the mill were tagged for proper sequence of delivery.

The new mill which had been erected on a temporary foundation outside of the mill was dismantled, match-marked, and main housings placed on lowboys for transferring into the mill.

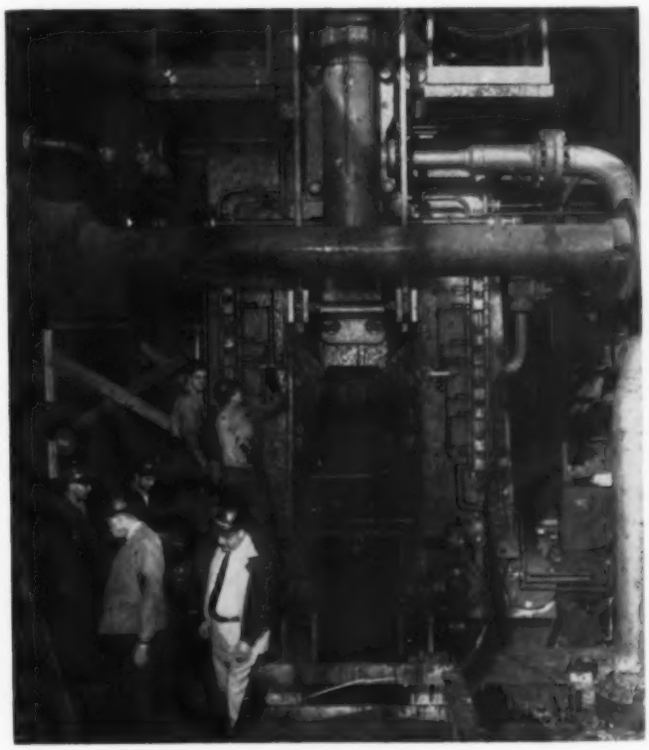
Figure 12 — Covers are being installed for lower motors— September 14, 1953.

Figure 13 — Inspectors are checking spindle retriever after fishtail installation — September 14, 1953.

On September 8, 1953, the mill went down at 8:00 am for conversion. It was amazing to see the spirit with which the men entered into this job. Every man was in his place that morning, and every man knew exactly what to do and when to do it. When the mill blew down, all safety precautions were taken first and then actual work began.

The workmen who were assigned to the motor room job stayed on the same turn during the complete job. This was also true of the millside. As this job was actually in two different buildings, a schedule and a thermometer bonus chart was posted on each side

Figure 14 — Mill is now ready for rolls — September 15, 1953.



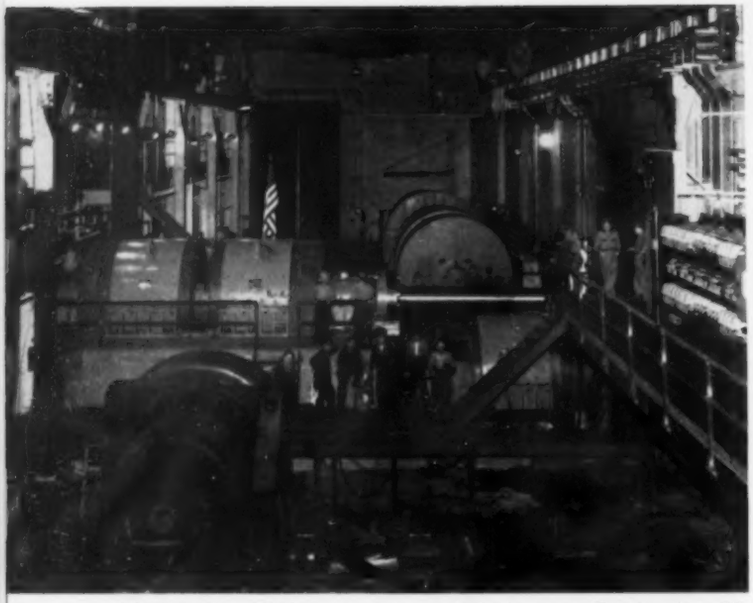


Figure 15 — Motors are now ready to go — September 15, 1953.

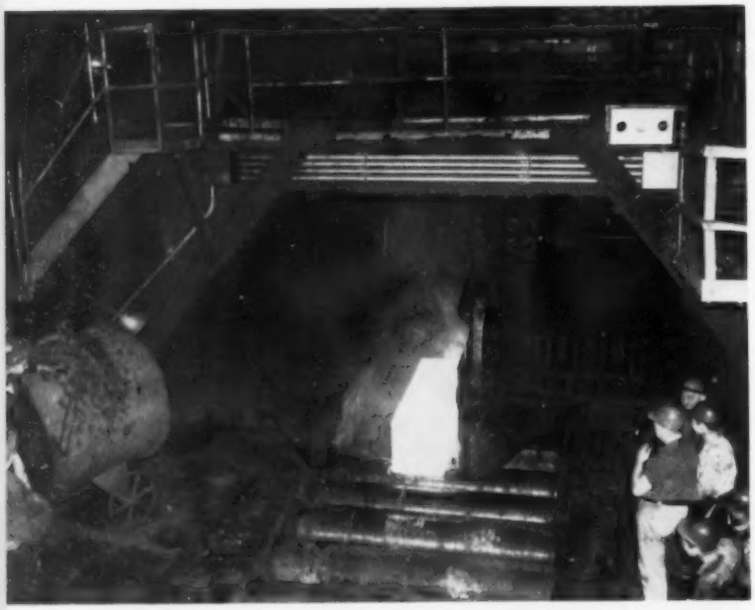


Figure 16 — First ingot is shown passing through the mill. Actual time of changeover of 7 days 14½ hours bettered the master schedule of 9 days 20 hours by more than 2 days — September 15, 1953.

which enabled the men to check as to the progress of the job.

Soon after the conversion job started, it was plain to see that the problem was not the problem of meeting the schedule, but actually then became the question as to what extent this schedule could be beaten. A

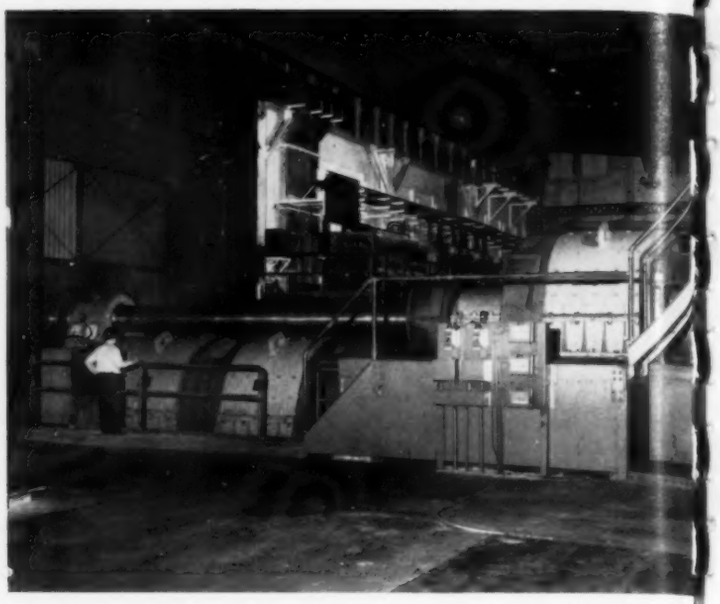


Figure 17 — Final cleanup in motor room is practically complete — September 20, 1953.

spirit of rivalry existed between the men assigned to the mill and the men assigned to the motor room. This will to win and the sporting attitude of the men was reflected from the weeks and months of careful planning and co-ordination which made possible this high degree of efficiency. Exactly 7 days-14½ hr after the last ingot was rolled with the old mill and steam drive, the first ingot was rolled on the new mill. As the master schedule of 9 days-20 hr was considered as a goal to attain, the actual time of 7 days-14½ hr achieved was indicative of the results possible to attain with detailed planning, and the value of good personnel relations.

In all meetings "safety first" was emphasized, and the results were gratifying in that this conversion job was completed with a 100 per cent safety record.

During the first full turn after the motor drive was placed in service on September 15, 1953, the number of ingots rolled equalled the average of the steam engine driven mill.

In 8 weeks a new 24-hr day record was made in both number of ingots rolled and tonnage produced.

In December 1953 the number of ingots per 8-hr turn had again been bettered. Then on January 3, 1954, on one single turn of 8 hr, a new record was established in both the number of ingots rolled and the tonnage produced. Some 576 ingots were rolled during this 8-hr turn with an average of 72 ingots per hr. This was and still stands as the world's record for small ingots, but we at Aliquippa only consider this as a record to be broken.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

. . . . one of the chief benefits of continuous annealing is uniformity of product . . . . line speeds are still slow compared with many other production operations, but are on the increase . . . . one of major problems is the cooling rather than heating of the steel . . . .

Continuous Annealing of Steel Plate Strip

By HORACE DREVER, President, Drever Co., Bethayres, Pa.

▲ THE process of annealing tin plate strip by the continuous furnace, while not new, is yet not in common use although a very active interest is being given to it by those mills not yet equipped, the majority of the total number. There are at present six plants producing by this method, all however as part of the total annealing plant. There are three mills with annealing lines under construction in Canada and the United States and the first of such lines abroad is being completed in Wales. Active plans are on foot for other installations, either by those who have no continuous annealing lines or as added capacity by tin plate producers who already are producing by this method. With such activity under way, the subject is of interest to all who are involved in the making of tin plate.

The earliest furnace on a production scale was an electric vertical furnace installed at Baltimore in Crown Cork and Seal Co., in 1936. This was a two strip furnace with each strip rated 75 fpm and while this furnace was not economical because of the slow speed, it did demonstrate the feasibility of the method and led immediately to the construction of a second and a third line, the last with a nominal rating of 300 fpm and a top speed of approximately 380 fpm. The product from these furnaces was stiffer and harder than batch annealed plate and was looked on with skepticism by the steel industry in general, but it suffices to say that exactly the same qualities of plate are now yielded by the continuous lines that have been installed recently, qualities that are more and more being demanded by customers of the tin plate producers.

A few years after the Baltimore installation, the first gas-fired radiant tube furnace was built in the Ohio district as a pilot plant, but the metallurgists rejected the product as being harder and stiffer than batch annealed material and the line was dismantled. It did, however, demonstrate the practicability of gas firing in radiant tubes as the method of heating.

During World War II, the first line in Canada was put into operation by Dominion Foundry & Steel Co. and is still producing. This line is rated 300 fpm speed. The furnace is electrically heated with a rating of 1800 kw. A cleaner has since been installed ahead of the furnace, thus combining two operations. The product is used in quantities by the can makers and many other types of fabricators.

So much for the brief early history of the process. The question naturally arises why this method is so rapidly coming into favor for annealing tin plate strip, particularly when the heavy investment for even a modest sized line is considered. The major answer probably can be summed up in one word—uniformity; uniformity of physicals, uniformity of surface. With the rapid increase in speeds, accompanied by automatic operation, automatic forming equipment, uniformity of stock fed to the machine is the sine quo non. By its very nature, continuous strand annealing represents the ultimate in uniformity—batch annealing can never possibly approach it.

Other characteristics of strip annealed continuously are the absence of stickers, flatness and greater stiffness. All tin strip makers are acquainted with stickers which are encountered in the batch anneal and the trouble from them at the temper pass mill. This subject has been discussed by Swisshelm[1]* and will not be enlarged here. Flatness of strip is affected by maintaining a controlled, uniform back tension when the strip is at its most elevated temperature and therefore in the most plastic state.

A decided saving in processing can be realized if cleaning is combined with annealing, the already accepted procedure. This completely eliminates one entire operation, and the heavy separate investment required for a separate cleaning line, including feeding uncoilers, welder, bridles and terminal bridles and recoilers. Both alkaline and electrolytic cleaners are used, the selection depending on the nature of the rolling lubricant.

The ultimate capacity of the continuous annealing line has not yet been reached and no one can predict with certainty what this will be, but compared with speed of the tandem cold mill, the present operating and projected lines are slow. The fastest now operating is rated 1000 fpm on 30-in. x 0.010-in. strip and has run at speeds slightly in excess of this. A plant under construction is planned to run at 2000 fpm for a nominal output of 60 tons per hour of 30-in. x 0.010-in. material, and present thinking seems to agree on this rating as the objective for the larger mills, at least until advances in heating, cooling and tracking techniques warrant an attack on higher speeds. The advantages of higher speed are apparent. Given a coil of a certain weight

*Numbers refer to Bibliography at end of article.

and dimensions, the mechanical equipment to handle this, and the associated electricals, vary but little with speed and therefore the higher the speed, the lower the investment per ton of output becomes. Labor per line remains almost constant regardless of speed and therefore the cost per ton falls almost in straight line proportion to the increase in speed. Heat consumption is practically a constant per ton for any rated output. These factors are powerful incentives to attain the maximum speeds.

The furnaces used for the process are of two types, horizontal and vertical. The horizontal furnace has not been used for high production of tin plate, although it is reported that a 3-pass furnace of this kind, with heat recuperative characteristics, has been used in Germany for a rated output of seven metric tons per hour. In this country all furnaces in recent years have been of the vertical type, either for strictly radiant type heating, by gas or electricity, or else a combination of high-gradient heating followed by the usual radiant furnace. A variation of this is the combination of high-gradient preheating to 600 to 800 F, finishing to a maximum temperature in a radiant-heated furnace. The outstanding advantage of the vertical furnace is in economy of floor space and this type has become accepted as the standard form. A very good description of a vertical furnace line is furnished in the paper by Stone[2], and in the earliest paper on the subject by Seabold[3].

The heating and cooling cycle carried out in continuous annealing may be divided into four parts:

1. Heating to maximum temperature 1300 to 1350 F.
2. Soaking at maximum finishing temperature.
3. Retarded cooling to 900 F.
4. Final cooling to just above room temperature.

There is little or no agreement among metallurgists or furnace designers on what constitutes the optimum cycle and it is apparent that a wide variation of each step in the series above is permissible.

With radiant heating, the first step, i.e., heating to final temperature can be made in 15 to 20 seconds for 0.010-in. material, with a maximum furnace (control) temperature of 1800 F. This condition permits stoppage of the strip and restart without danger of strip breakage. Higher temperatures than this will cause a tear-off on restart and consequently a loss in production because of the necessity of re-threading. If high-gradient heating is used, upon slow-down or stoppage, the heating means must be instantly removed or else the strip will burn off and a re-threading operation will be necessitated. With this method of heating, material 0.010-in. thick can be heated to annealing temperature in two to four seconds.

The second part of the cycle, soaking, is used only as a factor to insure that the strip is heated right to the center and can be allotted 8 to 15 seconds.

Retarded cooling is considered desirable by most metallurgists. Just what time should be allowed this phase for 0.010-in. material remains to be determined. In six cases examined by the writer, the ratio of slowest to fastest was 2.3 to 1 and the properties of the annealed strip in all cases are acceptable by the ultimate user. The usual range for 0.010 material is from 15 to 27 seconds. The principal variable so far detected is the aging properties which can be compensated for in temper-passing.

The final step, cooling to final temperature, presents as difficult a problem as heating to annealing temperature. All surfaces of the strip must be exposed to a sufficient area of water-cooled surface for a sufficient time element to transfer its heat by radiation, and as the strip is bright, its radiation factor is a minimum, and hence cools slowly. The recent trend in design of this part of the equipment is to cool down in enclosed chambers to approximately 400 F and then quench in water followed by hot air blast drying. The metallurgical properties of the steel are not affected by this quenching, but considerable time and equipment is saved. Any improvement in cooling rates appear to lie in the direction of combined radiation and convection heat transfer means.

Thus it appears paradoxically at the present time, the furnace builder must turn his ingenuity towards vastly improved methods of cooling rather than heating the steel. Even with the mechanical and electrical means, now available, which permit strip speeds in other processing lines of many times the fastest envisioned speed of 2000 fpm for any annealing line, it is certainly short-sighted to foresee extension by multiplicity of present cooling passes to permit such speeds. A marked departure from present thinking and conventional designs of cooling means, is the only answer to extension of annealing line speeds much over that being achieved today.

The physical characteristics of the product of the continuous annealing furnace have not been discussed for the reason that these have been discussed authoritatively by Seabold, Weir and Swisshelm in this country and by Dr. Erich Schauff abroad. A reference to these papers is found in the Bibliography.

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DISCUSSION

PRESENTED BY

E. J. SEABOLD, Consulting Engineer, Baltimore, Md.

E. J. Seabold: In the early stages of tinplate strip annealing, extensive tests were conducted in an attempt to shorten the final cooling cycle. One set of tests involved the use of water cooled rolls. Top and bottom strip support rolls located near the exit end of the cooling chutes were redesigned to include water cooling the strip support area.

Type of rolls used were 22-in. outside diam, 48-in. face, double barrel with 2-in. water jacket. Drilled pipe headers, located diametrically opposite, were in-

serted in the water jacket for uniform distribution of the inlet and outlet water.

In test operation with 30-in. wide and 0.010-in. thickness strip, results indicated positive distortion of the strip, caused by local chilling at the point of strip contact with the roll, at all times when the strip temperature approaching the roll exceeded approximately 650 F. Strip speed-up and slow-up clearly indicated the temperature range between flat and distorted strip. At the time of tests, cooling water entered the roll at about 80 F and discharged around 120 F. Tinplate strip even slightly buckled by roll cooling was found to be very difficult to shape on the temper mill without losing properties desired for a specific temper range.

The initial design of roll did not include the drilled distribution headers. Consequently the roll face temperature, being slightly cooler on the entry water side, was responsible for cooling one edge of the strip more than the other with the result that the strip moved over toward the cooler tight side and a strip break was inevitable. This condition of cooling one edge at a faster rate prevailed on all rolls when tested separately through the strip temperature range of 650 down to 250 F, the exit temperature.

Conclusions were that water-cooled roll cooling of the strip is possible below a temperature of 600 F, however, a continuous train of rolls would be necessary for the shortest length of strip and these rolls would be located inside a gas tight casing. Using strip support rolls only was considered rather ineffective compared to a water quench tank, wringer rolls and dryer.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, November 26, 1956 — Cocktail Hour 6:30 P.M.

Dinner 7:00 P.M., Meeting 8:00 P.M.

"Southern Research Solves Problems for All Industry," by F. R. O'Brien, Assistant Director, Southern Research Institute, Birmingham, Ala.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, November 13, 1956 — Dinner 6:30 P.M. Meeting 8:00 P.M.

"The Niagara Mohawk Power System," by Harold Howell, Chief Project Engineer, Niagara Mohawk Power Corp.

Hotel Sheraton, 715 Delaware Avenue, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, November 6, 1956 — Dinner 6:15 P.M., Meeting 7:45 P.M.

"The Role of Research in the Steel Industry," by M. W. Lightner, Vice President, Applied Research, United States Steel Corp., Pittsburgh, Pa.

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, November 20, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

Details not available.

The University Club, 3813 Euclid Avenue, Cleveland, Ohio

DETROIT SECTION

Tuesday, November 13, 1956, Dinner 6:30 P.M., Meeting 8:00 P.M.

"Power Reactor Plants for Industrial Use," by Jeff Mellor, Engineer, Power Generation Engineering Section, General Electric Co., Schenectady, N. Y.

Dinner and Meeting — Frolic Club, Oakwood Blvd., Dearborn, Mich.

LOS ANGELES SECTION

Monday, November 12, 1956 — 6:30 P.M.

"Rolls and Effects," by E. G. Lindsey, General Foreman Roll Shop, Cold Reduction, Columbia-Geneva Steel Division, United States Steel Corp., Pittsburg Works, Pittsburg, Calif.

Rio Hondo Country Club, 10627 South Old River School Road, Downey, Calif.

PHILADELPHIA SECTION

Saturday, November 3, 1956 — Dinner 6:00 P.M. Meeting 7:00 P.M.

"Revaluation of the 84-In. Plate Mill Modernization at Alan Wood," by Frank J. Bampton, Superintendent of Blooming Mill and Plate Mills, Alan Wood Steel Co., Conshohocken, Pa.

"Spraywelding — A Hard Facing Preventive Maintenance Process," by Jay R. Smith, Development Engineer, General Mechanical Department, Bethlehem Steel Co., Steelton, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, November 12, 1956 — Social Hour 6:00 P.M. Dinner 7:00 P.M., Meeting 8:00 P.M.

"Fatigue Failures in Ore Bridges — A Review," by Harry C. Prince, Designer, American Bridge Division of United States Steel Corp., Chicago, Ill.

University Club, University Place, Pittsburgh, Pa.

SAN FRANCISCO SECTION

Tuesday, November 20, 1956 — Social Hour 6:00 P.M. Dinner 7:00 P.M., Meeting 8:00 P.M.

Judson Steel Corp. Night

"Some Applications of Electric Equipment for Rod, Bar and Merchant Mills," by J. A. Reed and A. J. White, Steel Mill Application Engineers, General Electric Co., Schenectady, N. Y.

Shattuck Hotel, Durant and Shattuck Streets, Berkeley, Calif.

YOUNGSTOWN SECTION

Monday, November 26, 1956 — Social Hour 6:00 P.M. Dinner 7:00 P.M., Meeting 8:00 P.M.

"The St. Lawrence SeaWay — An Investment in the Future," by William A. Callendine, Technical Assistant to the Vice President in Charge of Planning and Development, Republic Steel Corp., Cleveland, Ohio

Mahoning Country Club, Girard, Ohio

GEAR TOOTH

By JOHN J. STOLZ

Assistant Vice President Engineering

Tool Steel Gear and Pinion Co.

Cincinnati, Ohio

▲ GEARS are a common method of transmitting power or rotary motion from one shaft to another. They have an advantage over friction or belt drives in that they are positive in action. Most steel mills and general machinery applications require positive action, since speed ratios are essential. Friction and surface-contact drives have some use in industry, particularly where high speeds and light loads are encountered or, in a few cases, where the drive is subjected to impact. A gear differs from a friction disc in that it has projections or teeth built upon the circumference so that they may transmit motion through the meshing of the teeth without slippage.

The invention of gear teeth represents a gradual evolution from gearing of primitive form. The earliest evidence we have of an investigation of the problem of uniform motion from gearing, and a successful solution to that problem dates from the time of Olaf Roemer, a Danish astronomer, who in the year 1674 proposed the epicycloidal form to obtain uniform motion. The involute form as we know it today was suggested as a theory by early scientists and mathematicians, but it remained for Willis to present it in a practical form. This was about the year 1695 and it was not long after the original demonstration of the epicycloidal form. The applicability of the involute had further been discussed by Leonard Oyler, a Swiss mathematician born in Basil in 1707. He is given credit as being the first to suggest it.

Looking at the subject of gearing from the standpoint of the uninitiated, it is easy to visualize his confusion or frustration when confronted with a gear problem. Generally the first instinct is to determine the type and the size of the gears needed from the standpoint of strength. He does not have the detailed appraisal knowledge of the art and its many ramifications to guide or assure him in his selection. He is not familiar with the evolution of gearing and the influence of old practices on the present-day facilities and designs.

The practice of resorting to old drawings plays a major role in guiding him in his selection of pitch, tooth form, material, etc. Very often spare gears are ordered for old equipment which should be changed to suit modern cutting practices. Unnecessary special tooth shapes penalize the customer in price, extra tool charge, and long deliveries. Much of the special tooth design is handed down from the cast-tooth era which accounts for the substituted, off-brand, cut-tooth gears in older equipment today.

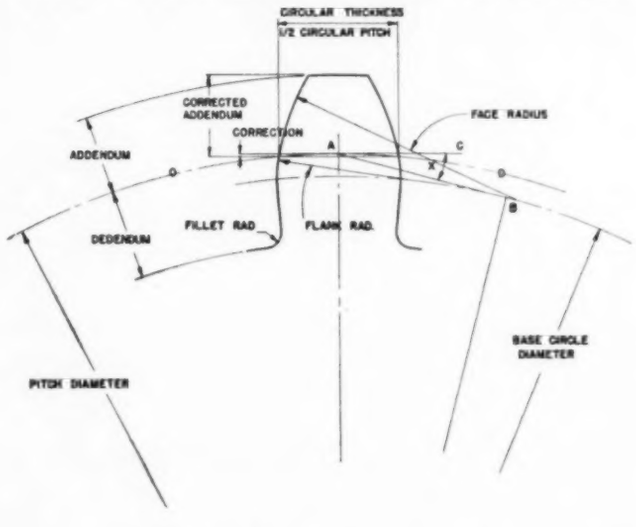
Gearing is a science but it requires considerable art to make this science practical. It is based on experience covering many variables all of which have their influence upon the final gear selection.

In view of the following variables, it can be readily seen that each can exert its effect upon the ultimate selection of the gears:

1. Space limitations.
2. Ratio.
3. Velocity.
4. Load.
5. Type of service.
6. Face and pitch diameter relations.
7. Material and hardness.
8. Tooth pressure angles.
9. Tooth proportion.
10. Helix angles.
11. Foundation.
12. Quality of workmanship.
13. Rigidity of the system.
14. Type of bearing mountings.
15. Lubrication.
16. Weather conditions.
17. Surrounding temperatures.
18. Operating practices.
19. Preventive maintenance practice.
20. Price and competition.
21. Noise-level requirements.
22. Life expectancy.
23. Accessibility.
24. Chatterless operation.

It is not too difficult to imagine the effect that these variables may have on the selection of a gear set if the users fail to recognize them. Quite frequently users of gears ordered to a pet material specification or no specification at all are at a loss to understand why their gears are not functioning properly. This procedure is also practiced by some of the equipment builders. The layout of the equipment is made with very little thought given to the gears or their lubrication, forgetting that the useful life of the equipment depends upon the proper functioning of its driving gears. As a rule, the

Figure 1 — Sketch shows nomenclature for gear tooth.



FORMS FOR STEEL MILLS

For all around gearing in steel mill service, the 20-degree pressure angle is now felt to be the best . . . . on large ratio gearing (higher than three-to-one), the 20-degree, long and short addendum, will give better tooth action and smooth, quiet operation.

above does not apply to enclosed drives and standard reducers, since they are all self-contained and incorporate factors for the variables in their design and are generally made according to the American Gear Manufacturers Association standard practices.

Figure 1 of a tooth shows the various parts which go to make it up. The arc OAD represents the pitch circle. The addendum of the tooth is the radial distance from the pitch circle to the outside diameter. Numerically it is equal to 1 divided by the diametral pitch, or 0.3183 in. times the circular pitch. This is for standard depth gearing. The dedendum is the radial distance from the pitch circle to the root of the tooth. It is equal to the addendum plus the tooth clearance. The clearance is obtained by dividing 0.157 in. by the diametral pitch or multiplying 0.05 times the circular pitch. The tooth thickness is measured on the pitch circumference and is ½ the circular pitch. In commercially cut gearing, a slight amount is deducted from the theoretical thickness to allow for backlash. A reasonable amount of backlash is required between the meshing gear teeth. If gears run with no backlash, or tight, generally speaking heat will develop which will ruin the gearing, particularly if it is hardened. A tight mesh will also not allow for an oil-film to spread over the tooth surface resulting in rapid wear, seizing or welding, and consumption of considerably more power. In hardened gearing, a certain amount of distortion is encountered, therefore a reasonable amount of backlash is necessary to assure free running.

Starting at 4 diametral pitch the normal backlash allowance is 0.003 in. to 0.005 in. on each member for backlash, progressively stepping up the amount until 1 diametral pitch has 0.018 to 0.020 in. This backlash is allowed on each tooth and the resulting total backlash between the gear and the pinion as measured by feeler gages will be doubled the amount just mentioned.

All gearing has as a basic starting point the pitch circle. In a pair of gears, the two pitch circles are tangent at a point on a straight line drawn through the axis of each gear. The next important part of the gear is the pitch. In all spur and bevel gearing there are two pitches; one is the diametral pitch and the other is the circular pitch. The diametral pitch is defined as the number of teeth to 1 in. of pitch diameter. For example, 15 teeth, 3 diametral pitch, the pitch diameter is 5 in., therefore, there are three teeth to each inch of pitch diameter.

The circular pitch is the distance from the center of one tooth to the center of the next tooth as measured on the pitch circle. To figure the pitch diameter of the gears having circular pitch, we multiply the number of teeth times the circular pitch times a constant 0.3183. This constant is the reciprocal of π or 1 divided by 3.1416.

When having either the diametral pitch or the circular pitch of a gear, it is a simple matter of mathematical calculation to convert one to the other. For example, if we have 3 diametral pitch to find the circular pitch we simply divide 3 into π and get a circular pitch of 1.0472 in. If on the other hand we have a circular pitch gear and wish to find the diametral pitch, we again divide 3.1416 by the circular pitch. This will give us the corresponding diametral pitch.

In helical and herringbone gearing, we not only have the circular pitch or diametral pitch in the plane of rotation; but we also have the diametral pitch or circular pitch in the normal plane, or the plane perpendicular to the helix angle.

Referring again to Figure 1, the tooth radius or contour from the pitch line to the outside diam is known as the *face radius*. The curvature from the pitch line down is known as the *flank radius*. The radius that joins the tooth to the root circle is known as the *fillet radius*. Note, a dimension is shown which is called the *corrected addendum*. This dimension consists of the standard addendum plus the height of the arc formed by a line cutting the tooth thickness at the pitch circle, as shown by the line AC. This dimension is used for measuring tooth thickness at a given depth with tooth micrometers.

The base circle radius shown in Figure 1 can be figured trigonometrically by multiplying the pitch radius times the cosine of the pressure angle.

The pressure angles generally used today are 14½ degree and 20 degree. The pressure angle can be defined as the line of pressure formed by a line tangent to the base circle of the pinion and the base circle of the gear cutting the tooth profile at the pitch circle.

The pressure angle of the 14½ degree was selected back in the cast-tooth era. Its natural sine is approximately ¼ and it was a convenient fraction for the gear engineer and the pattern maker when laying out teeth. In the conversion from the old cast-tooth era to the cut-tooth era, the 14½ degree pressure angle was carried through.

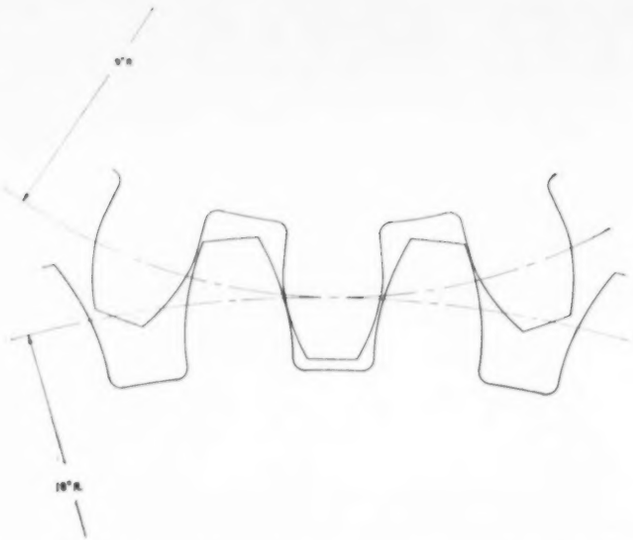


Figure 2 — Sketch shows 14½-degree pressure angle, 36-tooth gear in mesh with 18-in. pinion, standard depth, 1-in. DP.

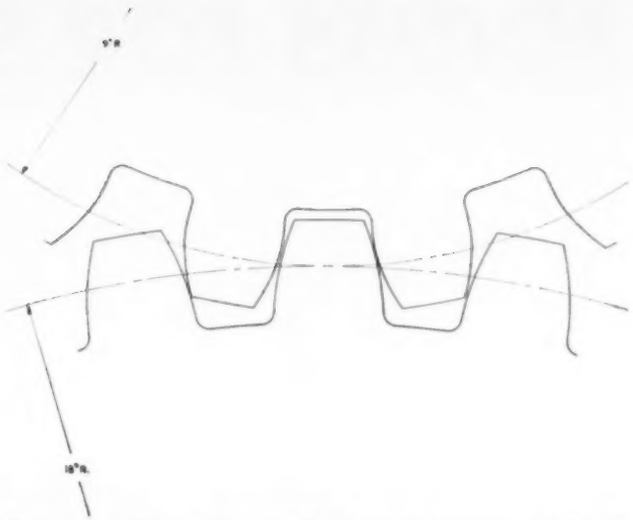


Figure 3 — Sketch shows 14½-degree pressure angle, 36-tooth gear in mesh with 18-in. pinion, stub tooth, 1-in. DP.

The 20 degree standard involute system is basically the same as the 14½ degree involute system as far as tooth parts are concerned. The only difference is in the pressure angle itself and the resulting change in tooth contour. As the pressure angle increases naturally, the base circle becomes smaller and with the tooth radii taken from a point on the base circle, one can readily see that the tooth will become more pointed at the top and much thicker at the bottom of the teeth.

We spoke before of corrected addendum and the method used for measuring thickness. Another method used in measuring tooth thickness is the pin or roll method. This method is very accurate, easily applied, and is also especially useful in shops where limited inspection equipment is available. Two cylindrical pins of a predetermined diameter are placed in diametrically opposite spaces. If the gear has an odd number of teeth, the pins are located as nearly as possible to diametrically opposite spaces. The measurement over the outside of the pins is then made with outside micrometers. The value of this micrometer dimension is determined by the use of involute trigonometry to be found in any treatise on gearing. This method is undoubtedly one of the most accurate ways of measuring tooth thickness. Another method is known as the block measurement whereby through involute trigonometry, we figure the distance over anywhere from 2 to 6 or 8 teeth and then measure this distance with venier calipers.

The matter of tooth forms, pressure angles, etc., has been discussed pro and con for many years. The involute system which is used almost exclusively today is by far the best form and all of the modifications of the basic involute are based on opinion, operating conditions, and experience. There will always be applications where 14½ degree gearing will work satisfactorily, but the general trend, however, is to the 20 degree pressure angle system for reasons that will be brought out a little later.

Figure 2 shows a typical 14½ degree pressure angle gear and pinion in mesh. Note the gear and the pinion have rather straight-sided teeth which in action tend to slide considerably more than roll. This action will result in slightly faster wear on the profile. The gearing is not as strong as the 20 degree pressure angle gearing. The 14½ degree pressure angle gearing is used to a large extent in industry today; however, it is gradually being replaced by the 20 degree involute system.

The stub tooth, 14½ degree, pressure angle gearing is shown on Figure 3. Note that this form is identical with the parent standard depth gearing except that the height of the tooth has been shortened. This stubbing or shortening of the tooth height results in a definite lessening of the arc of contact. In commercially cut or hardened gearing held within commercial tolerance, this type can cause very noisy and rough gear tooth action, due to inaccuracies in the machine tool and the cutting tools. These inaccuracies allow the driving tooth to come out of mesh a fraction before the next tooth has taken its share of the load. Stub tooth gearing is approximately 20 per cent stronger than the standard-depth gearing. The 14½ degree stub gearing is used very little at the present time and it also is being replaced by the 20 degree, pressure angle gearing.

Figure 4 shows the 20 degree form which is good from both the standpoint of strength and smooth tooth action. This form has the same addendum, dedendum, and thickness as the 14½ degree form, the only difference being in the pressure angle and the resulting tooth contour. This form does not have such straight-sided teeth and in action will give good, smooth operation. The 20 degree standard depth gearing is considerably stronger than the 14½ degree gearing. For general applications, such as crane gearing, general mill gearing, machine gearing, speed reducers, etc., this form is exceedingly good. We as gear manufacturers very highly recommend it. The 20 degree pressure angle gearing does have a somewhat greater separating force; however, it is not sufficient to give any trouble on rigidly mounted bearings, either bronze or anti-friction.

The 20 degree, stub tooth gearing shown in Figure 5 has the disadvantage of a short arc of contact due to its lesser depth. It is more critical in operation and due to slight inaccuracies can have very poor tooth contact and be very noisy in operation. Here again about all we

can say for this type gearing is that it has approximately 20 per cent greater strength than the 20 degree standard depth form. Generally speaking, the 20 degree stub form is used considerably in small or light pitches and small sizes where high accuracy can be obtained. It is also used where high speeds are encountered, such as an automobile transmission and similar drives. Shaving or grinding for extreme accuracy is necessary for this type gearing. On spur and bevel gears, we do not recommend using 20 degree stub depth if we can help ourselves. However, we do produce a lot of stub gearing in heavier pitches. Being gear makers we produce all types to customers' specifications. There are many applications in steel mills that use the 20 degree stub form. To mention a few of these would be the herringbone mill pinion drives, the table bevel drives, and many helicals used throughout the mills. We believe that the 20 degree stub is good for herringbone and helical gears. In most cases the helix angle is anywhere from 15 to 30 degrees. There is sufficient overlap of the teeth to give smooth operation and at the same time gain the extra strength feature of the 20 degree stub.

The 20 degree long and short addendum gearing shown in Figure 6 was developed many years ago for street railway service. It was necessary at that time to have a stronger pinion. Due to design, the pinion had no outboard bearing support and a rather large armature shaft so that it would have been objectionable to use the shorter or stub tooth form. The manufacturers decided to make the addendum of the pinion longer and the dedendum shorter and still maintain a standard depth tooth. Consequently, on the mating gear, the addendum had to be made shorter and the dedendum deeper. These gears and pinions are cut with standard 20 degree hobs. They will give much smoother action resulting in quieter operation. They have considerably greater strength than the parent 20 degree standard gearing. This can be seen in the greater thickness of the pinion tooth at the root or critical breakage area. Also in this design, the pinion and gear approach equal strength. In standard gearing, particularly pinions having low numbers of teeth, the pinion is not nearly as strong as the gear. The 20 degree long addendum gearing is particularly good where the number of the teeth in the pinion is small. This type gearing almost completely eliminates undercutting of the tooth below the pitch article. When ratios exceed 3 to 1, long and short addendum gearing is particularly good. It should be used to a much greater extent than it is. It would be exceedingly beneficial on the motor drives of cranes, charging machines, etc.

Comparisons of the tooth forms are shown on the following figures: Figure 7 shows 14½ degrees standard depth tooth in solid lines and the 14½ degree stub form in dotted lines. It will be noted that the general profile is identical except for the depth of the teeth. In operation the stub due to its shorter depth does not stay in mesh as long as the standard depth gearing does and as stated before can be somewhat noisy if not made with extreme accuracy.

Figure 8 shows the 20 degrees standard and stub form superimposed. The same results just mentioned will prevail.

Figure 9 shows a 14½ degree tooth in solid lines and

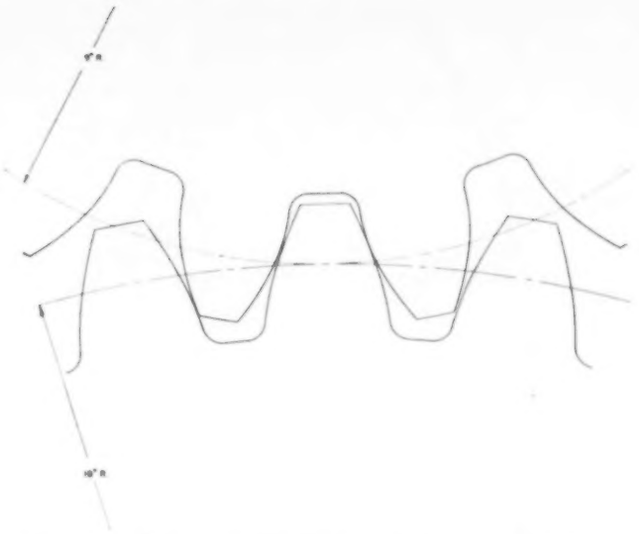


Figure 4 — Sketch shows 20-degree pressure angle, 36-tooth gear in mesh with 18-in. pinion, standard depth, 1-in. DP.

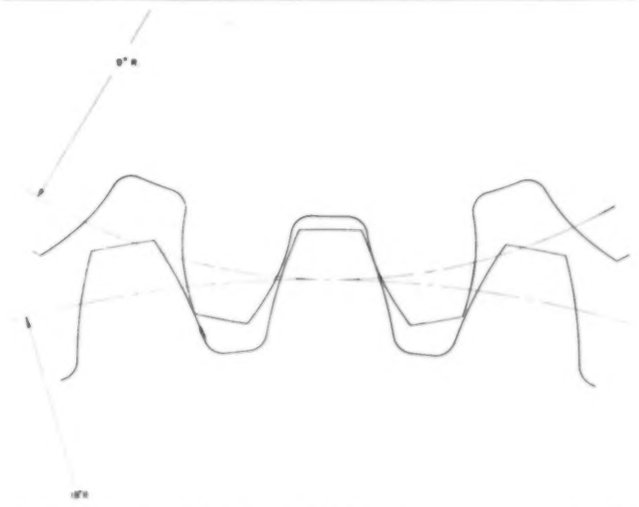
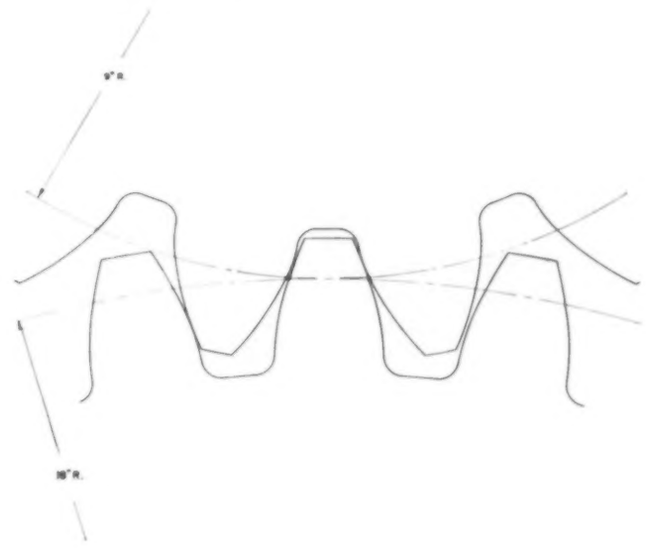


Figure 5 — Sketch shows 20-degree pressure angle, 36-tooth gear in mesh with 18-in. pinion, stub tooth, 1-in. DP.

Figure 6 — Sketch shows 20-degree pressure angle, 36-tooth gear in mesh with 18-in. pinion, long and short addendum, 1-in. DP.



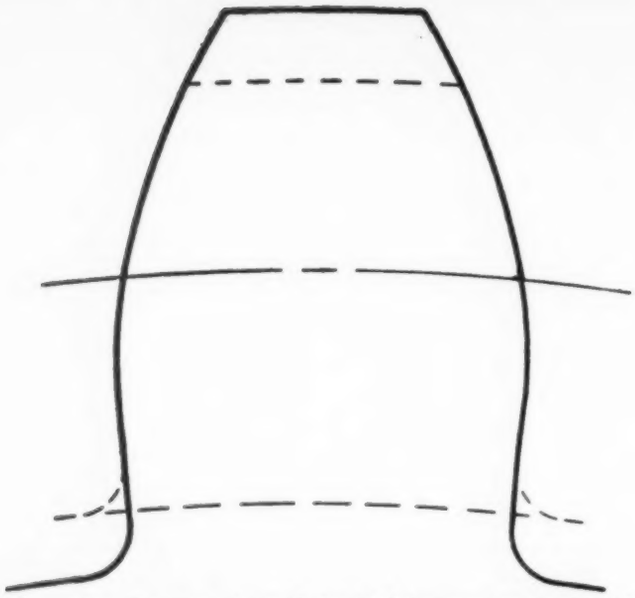


Figure 7 — A comparison of the 14½ degree standard tooth shown solid and the stub form emphasizes the greater bending strength of the stub tooth.

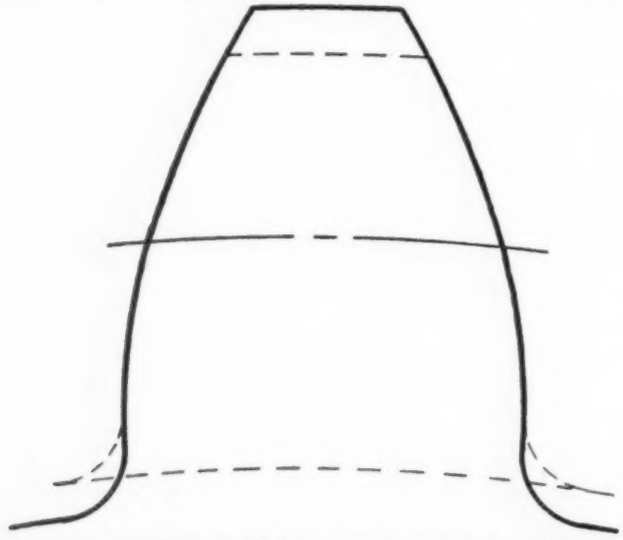


Figure 8 — With the 20-degree pressure angle, the stub tooth also has greater strength.

a 20 degree tooth in dotted lines. The greater strength of the 20 degree profile can easily be noted due to the greater thickness of the tooth at the root section. Also it can be seen that the 20 degree tooth has greater curvature for considerably better tooth action.

Figure 10 at the right shows a 20 degree long addendum profile in solid lines and a 20 degree standard profile in dotted lines. This again shows the greater strength of the long addendum standard over the 20 degree standard gearing. This type gearing is in general use today on practically all diesel electric and straight electric locomotives and has been accepted as a railway standard. It is very good where the number of teeth in the pinion is small, such as motor pinions on cranes, etc., as there is no undercutting below the pitch line. It is a much stronger tooth. The greater curvature of the tooth results in a much smoother tooth action.

The higher separating force of higher-pressure angle gearing was discussed earlier. When changing from one pressure angle to another, the increase in bearing loads

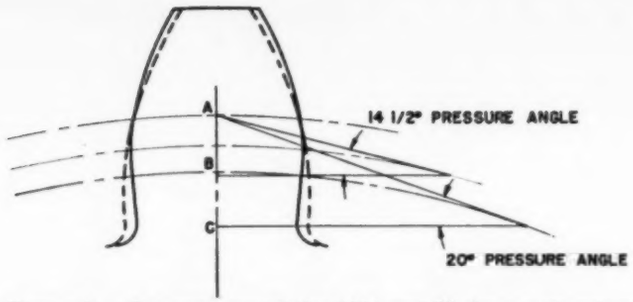


Figure 9 — Comparison of the 14½ and 20-degree standard tooth form emphasizes the greater strength of the 20-degree tooth.

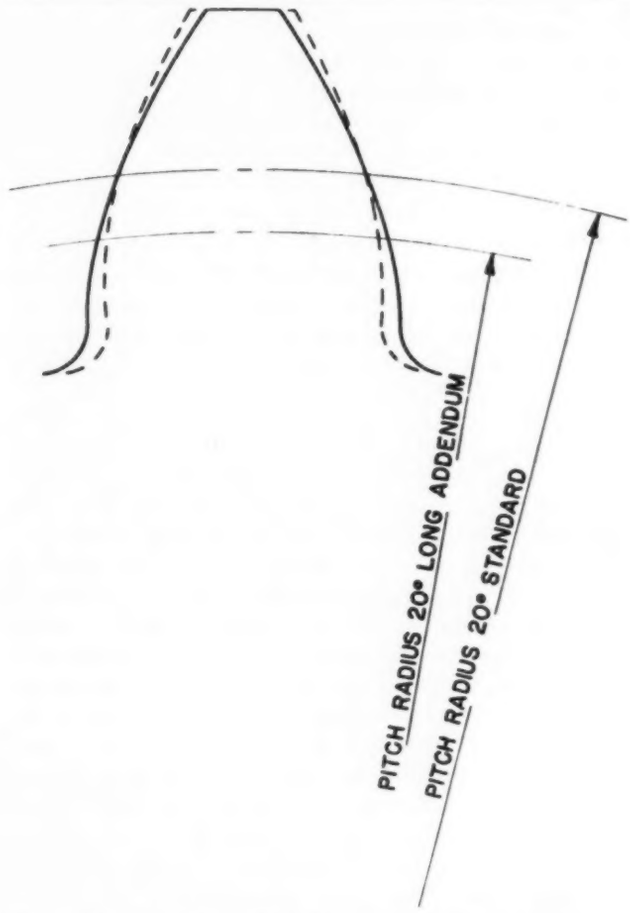


Figure 10 — The long addendum tooth has greater strength than the standard depth tooth.

Figure 11 — This formula is usually used for computing bearing loads.

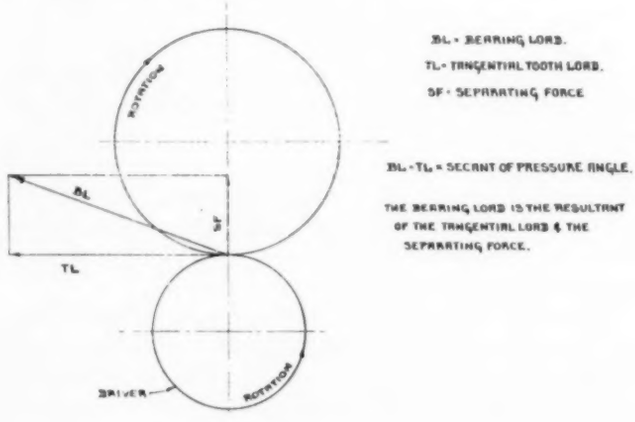


Figure 12

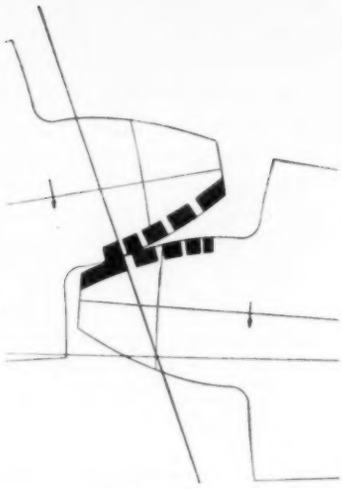


Figure 13

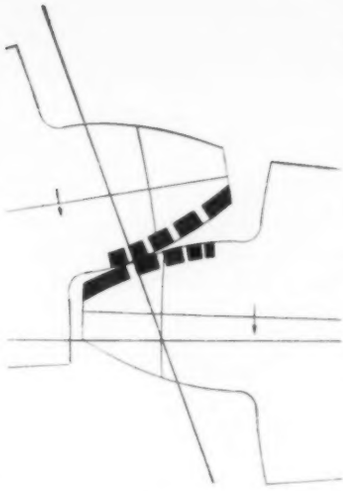


Figure 14

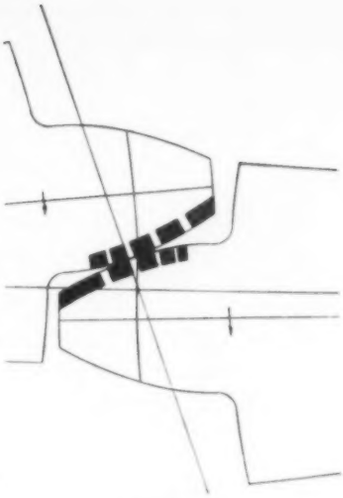


Figure 15

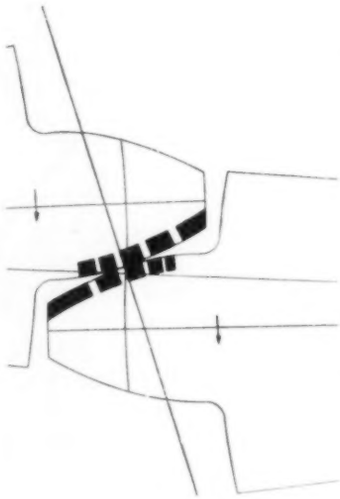


Figure 16

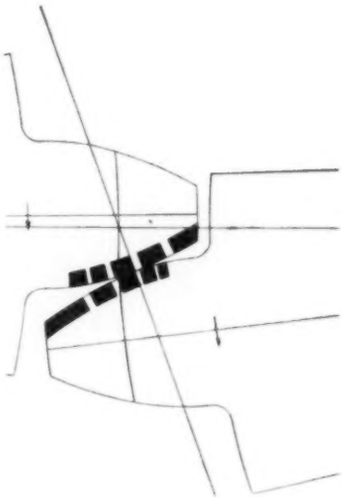


Figure 17

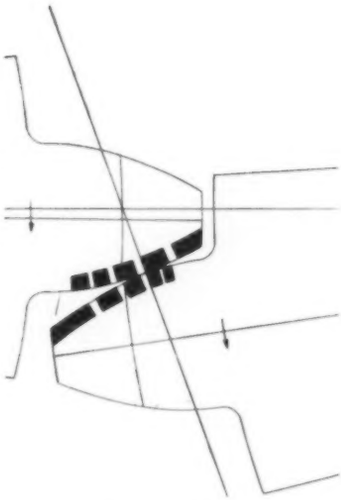


Figure 18

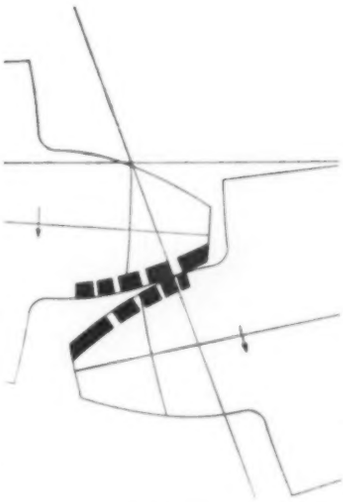


Figure 19

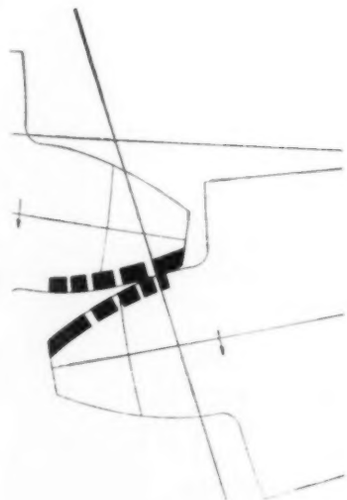


Figure 20

Figure 12-21 — This series of figures shows the action between the pinion and the gear of two 20-degree, full-depth gears from the time that the driver shown on the left comes into contact (Figure 12) until it leaves the driven tooth (Figure 21). At first the driver has little area of contact compared with the mate (sliding contact), halfway through the cycle the area of contact is roughly the same (rolling contact), and at the end of the cycle the driver has a larger area of contact. The greater comparative wear takes place on the portion of the tooth with the smaller area of contact.

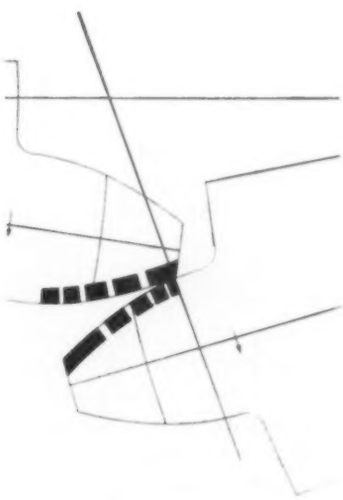


Figure 21

is dependent upon the increase in pressure angle. For example, in comparing the higher-pressure angle gears with 14½ degree pressure-angle gears, we find the following:

Seventeen degree pressure-angle gearing actually increases the load on the bearings by 1.2 per cent; 20 degree pressure-angle gearing increases the loads by 3 per cent; 22½ degree pressure-angle gearing increases the bearing loads by 4.8 per cent; 25 degree pressure-angle gearing increases bearing loads by 5.9 per cent; 27½ degree pressure-angle gears increase the bearing loads by 9.1 per cent; 30 degree pressure-angle gearing increases the bearing loads by 11.1 per cent. From this one can readily see that it is not at all detrimental to the bearings to change from 14½ degree to 20 degree pressure-angle gearing as far as additional bearing loading is concerned. Actually the results gained in stronger gearing and smoother tooth action is well worth considering. The 20 degree pressure-angle gearing is by far the best all-around gearing for good performance and it is highly recommended, generally, by responsible gear makers.

Figure 11 shows the formula for computing bearing loads.

Most engineers have heard statements made as to how gear teeth roll in action. Actually there is considerably more sliding of the tooth surfaces than rolling.

Figure 12 shows a pair of 24 teeth, 1 DP, 20 degree, full-depth gears in starting mesh. The profile of these teeth has been divided in such a way as to clearly illustrate what takes place in action. On the left side of the figure the driving tooth is in mesh with the tip of the driven tooth. Contact is made between the driver and driven teeth at a tangent point of the profiles, following on the line of pressure of the teeth of the actual pressure angle. The profiles are always tangent to each other on this pressure line throughout the complete cycle of mesh. In Figure 13 the teeth have completed the first cycle of mesh. Note the difference in the area of contact between the driver and the driven member. The driver has had a very small area of contact with the mate; while the driven member has had approximately 2¼ times the area. This indicates the greater eventual wear that will take place on the driving member.

Figures 14 and 15 show the contact pattern as the tooth curves approach the pitch-line area. Figure 14 indicates the start and Figure 15 shows the completion of this portion of mesh. The ratio of slide to roll is considerably closer; however, the driving member is still taking the greater of the wear.

Figure 16 now shows the addendum portion of the driver contacting the dedendum portion of the driven member. As the meshing cycle progresses, Figure 17 shows clearly that the driven member is now receiving greater wear due to the shorter contact length.

Figures 18 and 19 continue to show the greater wear area on the driven member.

Figures 20 and 21 show the final cycle of mesh, with Figure 20 showing the start and Figure 21 the finish. Here one can see the greater ratio of slide to roll.

These figures showed 20 degree pressure-angle gearing. The 14½ degree gearing would show even greater slide ratio. Actually as the pressure angle increases, the ratio of slide to roll is lessened. In studying this subject, one can understand why gears have a tendency to show heavy wear in the dedendum area. Naturally, soft gears will break down in this area very rapidly. As soon as the true profile starts to wear unevenly, greater in dedendum area than in the addendum area, noise and vibration are encountered. It is therefore advisable to use the best gear materials possible, sufficiently hard to resist as much wear as possible. In this way, the true profile will be maintained for a greater length of time, assuring smooth, trouble-free gear action.

As stated before, for all-around good gear design for steel mill service, the 20 degree pressure angle gearing is the best. On the large ratio items—3 to 1 and above—the 20 degree long and short addendum variation will immeasurably improve tooth action and smooth, quiet operation.

DISCUSSION

PRESENTED BY

E. M. GOODBAR, Division Superintendent, Maintenance, Columbia-Geneva Steel, Division of United States Steel Corp., Pittsburg Works, Pittsburg, Calif

E. B. RUSSELL, Assistant to Superintendent, Mechanical Shops, Kaiser Steel Corp., Fontana, Calif.

E. M. Goodbar: The author has effectively covered the types of gear tooth forms of general usage within the steel industry. We agree with his statement that considerable art is required to make the science of gearing practical. However, we must not overlook the fact that regardless of the tooth form selected and incorporated in the design, careful and painstaking workmanship is absolutely essential, in the production, assembly, fitting, and maintenance of gears. Other factors equally important are rigidity of the gear housing, accurary of machining of gear housing, adequacy of foundations on which the unit is installed, satisfactory alinement, proper design and installation of flexible couplings between the driver and the driven units. The materials for both the gears, the shafting and the housings, the hardness, and the heat treatment used, all are factors which materially affect the successful performance of all gearing.

For example, we know of units where the design is marginal, that have operated satisfactorily over many years, primarily because of accurate machining, proper fitting, careful assembly, careful maintenance, and the use of extreme pressure lubricants.

On a drag generator uncoiler gear reduction unit, the 20 degree stub, 2 DP gears and pinions were of ample capacity to support the overloads required of this equipment; and to be practical, the majority, if not all users within the steel industry overload equipment. However, the housing in this case, a weldment of 0.15 to 0.20 per cent carbon steel, was too soft to resist the pressure on the bearing outer races, resulting in severe distortion of housing bores, separation of gears by reason of this distortion, contributing to early failure. To correct these conditions, the housing bores were enlarged, and hardened sleeves of 300 to 320 BHN installed. This modification prevented continuing gear failure.

In many instances, distortion of housing bores has resulted from the failure of the designer, in the transition from the conventional sleeve type bearing to the anti-friction bearing, to fully recognize the fact that even though the anti-friction bearing may have had greater load capacity, it had also far less area in contact with the housing bore, and that the design of the bearing mounting was also equally important. Certainly these are important factors for the designer to take into consideration.

In another instance, excessive overheating and early failure of anti-friction bearings on high speed pinion stands was a serious problem within our operations several years ago. By substituting bearings with substantially increased radial clearance, overheating and bearing failures were eliminated, and these pinion stands have operated satisfactorily since.

We feel that it is important to minimize the number of gear tooth types in use in any plant in order to keep at a minimum, within such a plant, the required stock of hobs and cutters. This consideration is recognized in the AISE specifications for electric overhead cranes for steel mill service where selection of tooth forms is restricted to 20 degree full depth, 20 degree stub and 14½ degree full depth, and design data in tabular form is presented only for these types.

Our shop equipment includes full depth 14½ degree hobs for 6 DP to 2 DP; stub tooth 20 degree hobs for 5 DP to 2 DP, as well as 14½ degree form cutters from 20 DP to 2 DP. For routine gear replacement, and, of course, emergency replacement, in addition to these standard forms, we employ several long tooth distorted 14½ degree forms for certain galvanizing and hot dip applications. These are designed primarily to permit maintenance of roll contact by progressive shortening of center distances.

In new gear procurement specifically, and in procurement for replacement where practical, when the items are beyond the range of our shop facilities, we make every effort to furnish the supplier with all the available facts regarding the application, including arrangement and detail drawings, i.e., magnitude and frequency of shock loads; and in these cases, we make it clear to the vendor that we want the benefit of their design experience, and require that they select tooth forms, materials, and heat treatment which, based on their experience, is most suitable for the particular or specific application.

Mr. Stolz has referred to the failure of many users to modernize gear specifications when ordering spare gears for old equipment. It is, of course, necessary to fabricate or purchase gears for replacement in existing gear units that are compatible with the gears with which they must mesh. When gearing is replaced in entirety or in pairs, we endeavor to substitute the modern design, including, wherever possible, the 20 degree stub. As the author pointed out, the resultant increase in bearing load amounts to only 3 per cent, and normally requires no change to be made in the bearings or their mountings. The 20 degree form is predominant in the newer equipment, not only in our plant, but we believe in all plants. In addition to greater tooth strength, undercutting is not required when the number of teeth is 18 or more, instead of 32 teeth as in the 14½ degree gearing. Where untreated carbon steel gears have had short lives, heat-treated and alloy steel gears have generally been substituted.

The long-and-short addendum modification is used in our plant in our diesel-electric locomotive traction gearing, having been supplied by the manufacturers of this equipment for the reasons set forth in the paper such as increased strength of pinion teeth, smoother tooth action, plus elimination of undercutting. This system is considered in all cases when the number of pinion teeth falls below 18. The purpose, of course, is to eliminate undercutting and to provide smooth vibration-free operations.

E. B. Russell: The average layman's greatest difficulty with gearing lies in the complexity and multiplicity of detail involved. Just in the standard nomenclature that goes along with gearing in any discussion, the high percentage of mental concentration required to bear in mind the several nomenclature terms, makes it very difficult for the listener to grasp the theory behind any discussion.

In my discussion of this paper, it would seem that, "taking issue," with Mr. Stolz, in any areas in which we may not agree would serve only to confuse the several points so aptly illustrated in his discussion. My remarks will therefore be made with the sole purpose of endeavoring to enlarge upon the material presented in the hopes that a better picture of gearing as a whole will be taken home in the mind's eye of this group today.

First of all "standardization" is the hue and cry today, as it rightfully should be, and gear tooth profiles are not exempted. However, there are so many factors that may be varied in the design of good gear teeth that on the same gear problem several designers can come up with each a different designed tooth and still all meet the engineering requirements of an identical problem. For this reason standardization should be limited to such areas as that provided in the AGMA literature. In fully enclosed units such as speed reducers, worm drives, etc., this standardization has proven out, but on large drives of heavier pitches, the freedom of our gear engineers to utilize the fullest design possibilities of the involute curve properties should not be restricted to the extent that standardization becomes detrimental to the functioning and life of our gearing.

"Tip-relief" can be used as a good illustrative example. When the driving tooth of a pinion enters mesh with the tooth of its mating gear, theoretically, at the instant of first contact, two involute curves should touch tangentially to provide a nice sliding engagement. However, in practical application, accumulative errors in machining, etc., (particularly of standard formed cutters), result in tip interference.

Contact of the tips of the teeth against protuberances on the mating gear, near the base circle, creates one of the worst gear noises in a drive. Standard formed cutters when used in generating the larger mill drive gears, due to an inherent sensitivity, produce a thicker tooth at the base of the tooth being cut. When the top of the mating tooth comes in contact at the tip of the tooth on the instant of meshing, there is an interference at the tip of the tooth and generally surface damage follows. Edge contact at the beginning of mesh is always dangerous. It not only causes a sudden change in velocity

with the attendant noise that goes with it, but also tends to gouge out the surface profile of its mating tooth.

Another cause of this interference is the varying deflection of gear teeth caused by heavy intermittent loads of varying intensities, resulting in a differential in the amounts and periods of tooth deflection.

When tip interference occurs, it scrapes off the heavy lubricant film from the mating teeth and in effect, using shop terms, the gear runs dry resulting in excessive wear and noise.

In severe cases of heavy loading or where a hardened pinion tooth meshes with a softer mating gear heavy gouging takes place.

Where generating cutters are used, it is possible to design tip relief into the cutter by putting a radius or a curve on the tip of the cutter. In this respect no standardization should be so severe as to prohibit the gear specialist from doing this; particularly on the heavier pitches. Doing this to a generating cutter profile permits the cut gears to engage without tip interference and as normal wear takes place the contact ratio of the mesh increases and benefits the load carrying capacity of the teeth.

Of course it goes without saying that it is inadvisable to put excessive tip relief on spur gear teeth because there is no overlap of mesh such as you have in helical gears. This same tip relief can also occur between worm and worm wheels and similar steps are required to eliminate it.

On original installations when gears wear out and are replaced by other than the original machine-builder sometimes this tip relief is omitted; possibly because the original vendor has not shown on his drawings that tip relief is desired or because the replacement vendor, due to the exigency of delivery demands, uses standard cutters, assuming that tip relief will be put on by hand at assembly or worse yet, because the pertinent conditions and requirements of the drive are not passed on to the gear manufacturer. As a result, price, delivery and perhaps material are the only factors considered in the making of the gears.

When tip interference manifests itself, it is good preventive maintenance to promptly dress the teeth and, as wear progresses, considerable life can be added to the gears involved by stoning, pencil grinding or hand grinding the worn surfaces.

Backlash is an important factor on all gear sets, however, all that we will say on backlash is that all gears in general require sufficient backlash. Here standard "lash" as specified in the AGMA recommendations of 0.03 to 0.05/DP seems to cover general steel mill applications with the exceptions of special indexing, timing and large heavy drive gears.

I would like to comment here that backlash is no cureall for gear troubles as often assumed. While, in common mill practice, it is as a rule better to have more than too little backlash, still if gears develop noise or whine or rattle, it is not generally an indication of too little backlash particularly on new gears.

I do heartily recommend that backlash be shown on drawings, especially where departure is made from standard practices. For example, sometimes a builder will put all the backlash on the mating gear tooth and none on the pinion tooth of pinions having small numbers of teeth. He is of course trying to increase the wear life and strength of the pinion; however, when this data is not shown on the drawing, a new vendor will come along and unwittingly, split the backlash fifty-fifty. If he makes the new gear and it is assembled with a pinion purchased as an original spare, then the backlash is halved on the drive from what it was originally designed to have.

This of course brings up the question of changing gears in pairs. It is traditional of course to change gears in pairs and naturally to a conscientious gear man not to do so just is not in his book. In actual practice, however, there are times when it is expedient and mandatory because of lack of time, spares, or as an economy factor to do so, and gear manufacturers should do all that they can to provide for as near interchangeability as possible.

Being a maintenance man I cannot pass by the subject of preventive maintenance without a few remarks concerning gears.

All bearing caps on capsules, bearings and drives should be kept fastened tight because any movement of a bearing affects the alinement of the gears, with the consequent excessive wear or damage to the tooth profile we have discussed to such length today.

Replacing worn bearings is also critical to the life of a gear. A worn or loose bearing will run a long time before failure sometimes, and occassionally is permitted to do so under the illusion that bearing cost is being reduced; but this is poor economy when, while the bearing is being used up, an expensive set of accurately cut gears is gradually ruined in the interim.

Another important factor in relation to gear tooth profiles is the dressing of gear teeth. Any time a drive is opened up for whatever reason, the teeth should be inspected, and if roughing up from wear is starting should be redressed. Often just hand-honing a gear that has started picking-up will make the set last indefinitely, while if neglected, only a short life ensues. Burrs, lumps, nicks, any damage done physically to gear teeth should be avoided and, if done, rectified at assembly.

Wearing teeth at reduced speeds and loads is important, particularly on new installations and at times of replacement. All new gear teeth have imperfections in the teeth to some degree, no matter how slight and running in at reduced speed and load will give the tooth surfaces a chance to burnish down the otherwise slight imperfections which might, if high speed and load be applied, result in serious galling and seizure of teeth.

Bevel gears are an important part of steel plant operations, because of their many uses and the great number used in such places as mill tables.

In lineshaft driven mill tables, usually one heavy mill motor is used to drive the lineshaft. This means that should a bearing freeze in one of the table rollers, that the full overload horsepower capacity of the motor will be applied to that mitre gear on the roll with consequent heavy stalled torque loading on the tooth in mesh at that instant. For this reason, the 20 degree AGMA stub tooth seems to give the best life. Terrific shock loading is also present due to the reversing, stopping and frequent starting.

Misalinement due to capsules wearing back the

thrust fit of the table girders allows the table roller mitre gears to move out of their relative positions. Actually in a bevel gear drive, there is only one position at which a mitre gear will mesh properly with line contact. If a table roller gear moves out of mesh, correct tooth alinement cannot be obtained by sliding the driver gear along the lineshaft until the faces line up. All this does is result in point contact on one end of the teeth with the resultant concentrated load on one end of the teeth giving terrific wear or tooth breakage.

Carburized gears with a soft core for shock and heavy loads and a hard surface (60 to 68 Rockwell "C") for wear seem to hold up best for long service life. An alloy steel bevel gear, heat-treated before machining and tooth cutting (300 to 400 Brinell hardness) will give a good tough core for resisting shock loads and subsequent breakage but will only give short wear life.

Alloy steel carburized gears do a good job, but a certain percentage of breakage is to be expected because of the hardening distortions and misalinements due to wear and operating condtions coincident with rapid and frequent reversals coupled with high shock loadings on bevel gears of reversing mill tables.

Drawings—always a bone of contention in any plant, naturally enter into the picture whenever you speak of tooth profiles and gear data. Where possible and practical, a special tooth shapes and proportions should be avoided. Most of the special tooth proportions and pressure angles are "hand-me-downs" from the cast tooth era, and where gears are to be replaced on old equipment still in use the drive conditions and characteristics should be carefully reviewed by a competent engineer towards going to the use of more modern gear teeth, thereby avoiding such things as concurrent with special gears such as price, delievery, special-tooling charges, new pattern, etc.

Material specifications should be kept up to date on drawings and also reviewed at the time of proposed replacement or ordering of spare gears. Often individuals in an organization, because they had trouble in one drive and were able to correct it with one certain material will insist that this same material be used as a cureall for every set of gears put on order without taking into consideration all the pertinent data relating to the conditions surrounding each individual drive.

Occasionally, on a new installation, a material failure will occur and other material is substituted. Neglect to revise the drawings will carry the risk of buying spares some day or some months later furnished of the same original material that was unsatisfactory.

Where gears are purchased on a basis of price and delivery alone, especially where no material specifications are shown on the drawing and the traditional attitude of "let the vendor select the material—he knows best" prevails, the gears are apt to suffer as well as the more conscientious builders.

On increased center gear drives, cases have been experienced where the machinery-builder bored the gear boxes with long centers, but showed only standard center distances when dimensioning the prints. When repairs are made and the case is bored to print under these circumstances the gears naturally will not go in mesh. From this I would say that it is very obvious how important drawing dimensioning relating to gearing is to the customer. Builders that sell duplicate units of machinery over and over from the same prints certainly do not enjoy the good will of those having to use such prints.

In closing let us not overlook the relationship between good gear tooth profiles and lubrication. We cannot possibly enter into all the ramifications of lubrication at this time as it is a field quite similar to gearing in all of its complexities. However we should stop for a second to examine briefly the relationship of the two. When gears fail, it may involve tooth breakage or there may be any one of many tooth surfaces. Often we are prone to first blame lubrication. Tooth breakage is rarely due to faulty lubrication. Change in the structure of the tooth metal or excessive loading, or excessive surface speeds are usually the cause. Lubricants which normally afford ample protection to the tooth profile cannot keep the temperatures between the sliding surfaces of the teeth within reasonable limits under aforementioned conditions. Abnormal temperatures cannot continue without causing excessive friction followed by scoring, scuffing, welding and gaulding or surface cracking or softening.

In short, lubrication engineering should be on a par with gear engineering when designing a set of gears. Most reputable builders are doing this and those who are in the mills should reconstruct our thinking where necessary along the same lines.

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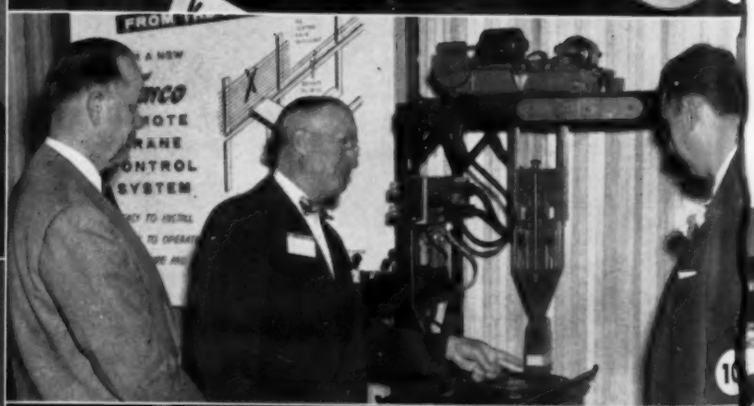

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Pictorial Review . . .

IRON AND STEEL EXPOSITION AND ANNUAL CONVENTION

CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

SEPTEMBER 25, 26, 27, 28, 1956

A total of 13,606 registrants (1) attended the 1956 AISE Annual Convention and Iron and Steel Exposition. This was the second largest turn-out in the history of the steel show.

The technical sessions (2) featured 44 papers by leading steel men. Electrical session members (3) included M. A. Nye, H. E. Watson, R. C. Suttle, H. R. Miller, and E. F. Donatic. Shown in (4) are J. L. Kerins, R. P. Petersen, K. L. Fetters, S. O. Evans, and P. D. Thomas, participants in the operating practice session. C. T. Lewis, second from right, (5) outlines procedures for fellow members of the lubrication and paint session: R. C. Hedlund, W. H. Ragborg and W. L. McCracken. Members of the operating practice session talk over some last minute details (6) left to right: W. E. Schwabe, G. I. Bottcher, W. E. Hart, W. B. Wallace, and E. S. Harman. In (7) are participants in the lubrication session: R. P. Mills, John Simon, Andrew Cichelli, C. A. Bailey, and Ben Holliday.

A program of activities was scheduled for the AISE ladies, a group of whom are shown (8) attending a luncheon at Higbee's lounge.

Equipment displayed by the 175 exhibitors in the show proved interesting for the registrants. The industrial truck drive unit (9) on display brought these registrants in for a close hand look. In (10), H. E. Davis, Republic Steel Corp. (center) questions John Taylor, about the remote crane control system as C. L. Squier, Bethlehem Steel Co., looks on. E. C. Denne explains features of his company's bearing to A. E. Allen, J. A. Buza, and A. G. Smith, Jr., Wallingford Steel Corp. Lou Hooper, left, (12) demonstrates a straightener to W. J. Assel, Ohio Seamless Co.

A reception for speakers table guests preceded the banquet held Thursday, September 27. Shown in (13) are: A. E. Glossbrenner, E. R. Johnson and V. H. Leichliter.

Winner of the Ford Thunderbird drawing was T. E. Cyphert, design superintendent of McDowell Co. In (14), T. J. Ess, managing director of AISE hands Mr. Cyphert the keys to the car as W. C. Friesel, exposition manager, looks on.

A portion of the more than 1300 guests who attended the banquet are shown in (15.)

By CHARLES E. SNEE, General Foreman, Assel Mill, The Timken Roller Bearing Co., Steel and Tube Division, Canton, Ohio

The Use of the Modern Assel Mill in Production of Seamless Tubing

▲ THIS paper deals with the development and use of the modernized Assel mill in the production of close dimension controlled seamless steel tubing.

A brief history of the development of the Assel mill is given, following which a detailed report is made of the unit and its operating characteristics as presently constituted.

HISTORY OF THE ASSEL MILL

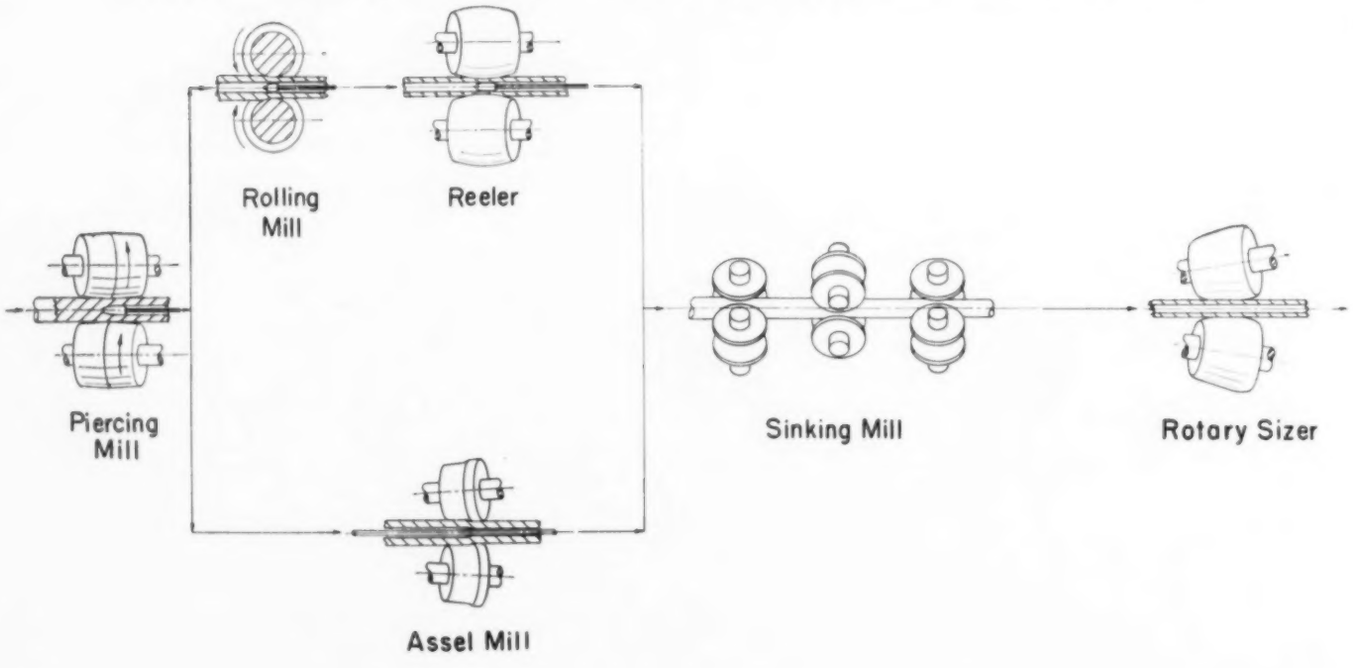
The Assel mill, or elongator as it is more often called, is a development of Walter J. Assel, whose purpose was to develop a cross-rolling mandrel bar mill which would perform the combined functions of the conventional plug rolling mill and reeling mills in the equipment necessary to the production of seamless tubing. It was also desired to improve control over wall variation and surface quality on the tubing so produced.

The first experimental work was conducted in the fall of 1932. Model sized wooden mills were used with extruded wax tubes as a rolling product. Mills of both two and three-roll types were tried with many varied roll contours including single and multiple reducing humps. In order to conduct these experiments, a slightly oiled wooden mandrel bar was inserted in the extruded wax tubes. The tube and mandrel were then inserted into the model mill being studied. Careful evaluation of the experimental results so obtained indicated that the most versatile unit for the range of sizes and sections required at the Timken Company was the three-roll mill with a roll contour of one reducing hump.

In early 1933, the first unit for the processing of steel tubing was built and further experimental work was conducted. The results obtained on this unit were so successful that the installation of a production unit was authorized for the company's Wooster plant. This production unit was started in March, 1935 and has been operating successfully ever since. Figure 1 graphically illustrates the location of the Assel mill in relation to the other equipment of a seamless mill.

The next Assel mill development was started in January, 1940 when the mill was modified for the production of high explosive shells for the armed forces. The experimental work was first conducted at the Timken Company's Wooster plant and this was followed by production installations and further experimentation by the National Tube Company. Eventually, a total of twenty-four special purpose shell units were constructed and installed at various locations throughout the United States. These Assel shell mills were built to produce a range of shells from 3 to 5-in. in

Figure 1 — Assel mill is located with relationship to the other equipment in the seamless tube mill.



. . . . this elongator will produce seamless tube with superior dimensional control in outside diameter to wall thickness ratios to a maximum of 12 to 1 at the elongator gorge . . . . in this country it is not primarily used as a light wall mill . . . .

diameter at a rate of up to 500 pieces per hour. When it is considered that the maximum production rate was 120 pieces per hour prior to the use of this process, the contribution of these mills to the war effort cannot be minimized. Some of these shell units were still in operation producing shells for the Korean War.

In 1946, an Assel elongator was installed in conjunction with the No. 3 seamless mill of the National Tube Company in Gary, Indiana. This unit was followed in 1953 and 1954 by other units in conjunction with the seamless facilities at Republic Steel Corp. Chicago, Illinois; Ohio Seamless, Shelby, Ohio; Tubes Limited, Leicester, England; and a second unit at The Timken Roller Bearing Co., Canton, Ohio.

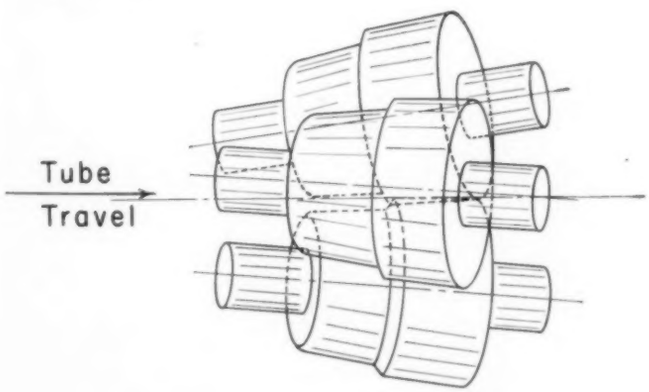
It is with the Assel unit installed in early 1953 at the Timken Company that the balance of this discussion is concerned.

THE MILL PROPER

In describing the Assel elongator, the longitudinal centerline of the work piece as it passes through the mill is also to be considered as the axis of the mill itself. Mounted at equal distances from this axis and from each other around the axis are three conical shaped work rolls. These rolls are suitably supported in tapered roller bearing chocks and are enclosed in a double mill housing.

One segment of this double housing is stationary while the other segment permits a rotation around the mill axis from 0 to 25 degrees. This rotation of the movable segment of the mill housing skews the work rolls around the central axis or working centerline of the mill. It is the selective rotary skewing of the work rolls around the centerline of the mill which provides the feed angle required to move the work through the mill. Figure 2 illustrates a typical roll cluster with rotation applied to provide feed.

Figure 2 — Typical roll cluster has three conical shape work rolls.



The geometric figure of the elongator is fundamentally that of a hyperboloid of revolution and this figure is represented as an elliptical view in Figures 3 and 4. In order to simplify these illustrations, just one roll is outlined and only the centerlines of the other two roll shafts are indicated. The additional lines in the figures are there to emphasize the basic geometric forms. Figure 3 illustrates the conic nature of the mill at 0 degree rotation while Figure 4 emphasizes the hyperboloid of revolution which is assumed when the movable housing is rotated to provide feed.

The cone of the work roll is so placed that the work enters the mill over the small end of the roll and leaves over the large end. This arrangement in combination with the feed angle tends to deliver an ever increasing component of feed to the work piece as it progresses

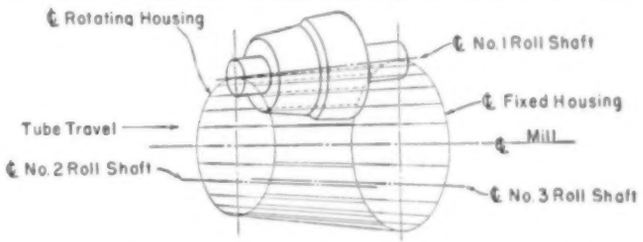


Figure 3 — Elongator is fundamentally a hyperboloid of revolution. One roll is shown without rotation.

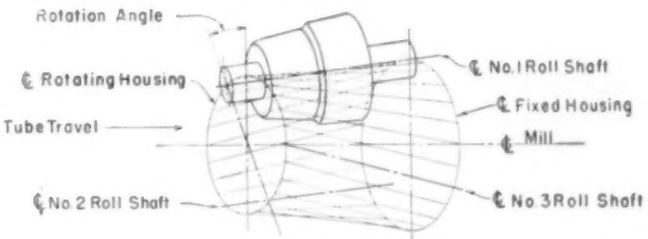


Figure 4 — Roll is shown with rotation to provide feed.

along the pass from inlet to outlet of the mill. This is the reverse of how the original elongators were installed, but it provides a much smoother operation.

The roll contour, as illustrated in Figure 5, is such that there is a clearance radius on the inlet end followed by a converging inlet surface at 3 degrees per side to the mill centerline. The converging inlet surface of the roll has the function of grasping the work piece, rotating it, feeding it forward, and sinking it onto the mandrel bar.

The inlet surface is followed by the characteristic Assel hump or working shoulder of the roll. This hump may be of a wide range of dimensions up to 1 in. in height. The most commonly used humps run from 0.218 to 0.312 in. in height and their selection depends upon the requirements of the individual user. The contour of the hump is derived by formula, as is shown in Figure 5. By way of explanation at this point, it should be mentioned that the factor of 1.71 as used

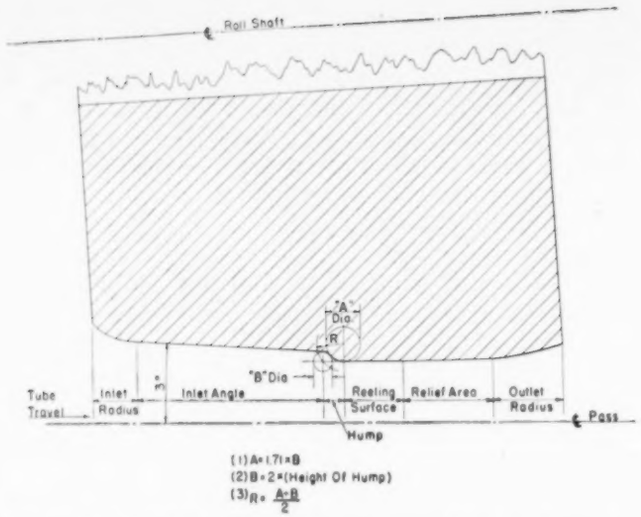


Figure 5 — Sketch shows roll contour and hump formula.

in the formula establishes the relative angularity of the hump. This factor of 1.71 was arrived at by experience in our mills and works well for us on the range of sections we produce, but should not be assumed to be applicable to all users.

Continuing along the roll beyond the hump, there is a short reeling surface which is parallel to the axis of the mill and which serves to round up the work, free it somewhat from the mandrel bar, and deliver the work piece from the mill. The reeling surface is followed by a gradual relief area and a final outlet radius. Roll diameters taken at the top of the hump run from a maximum of 18 in. to a minimum of 15 in. on the Timken mill, although some of the recent installations use a smaller minimum roll by reducing chock size. A rough approximation for determining the minimum size that any given elongator will make is to divide the roll diameter by 6 and add $\frac{1}{8}$ in. for clearance.

Other appurtenances of the mill proper include a hydraulic system which serves as a "pull-back" for the roll chocks, maintaining them in contact with the mill head screws. This hydraulic system also serves as the motive power for rotating the movable housing when skewing the rolls for proper feed angle.

The head screws which adjust for controlling the mill gorge or rolling pass are interconnected by lineshafts which move all three roll assemblies equally and simultaneously. Movement of the roll assemblies in respect to the mill gorge gives wall thickness adjustment on the work piece. The magnitude of this adjustment is indicated to the mill operator by means of a dial that is interconnected with the gorge drive and is calibrated to 0.001 in.

There are two separate lubrication systems for the mill proper. The roll chocks are supplied with lubricant at automatically timed intervals by a motor-driven pump. The mill windows and the rotating ways are supplied by a one-shot hand pump system.

Motive power for the elongator is supplied by a 2000-hp, dc motor. Speed is controlled through a range of 110 to 200 mill roll rpm from the operator's control desk. The speed reduction factor through the gear train from the motor to the mill is 2.35:1. The motor control is equipped for dynamic braking.

Figure 6 shows a view of the general area around the elongator with a shell from the piercer appearing next to the control pulpit on the right, the mandrel bar at the bottom of the picture, and a tube clamped in the inlet of the mill preparatory to the start of the rolling cycle.

Figure 6 — View shows mill from inlet side.

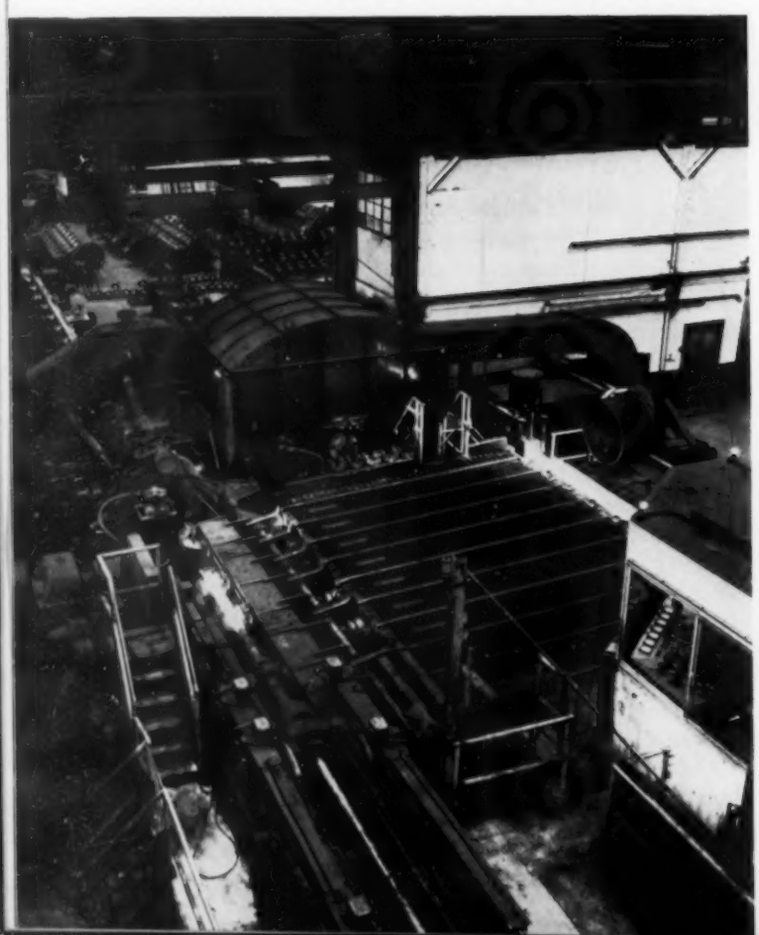
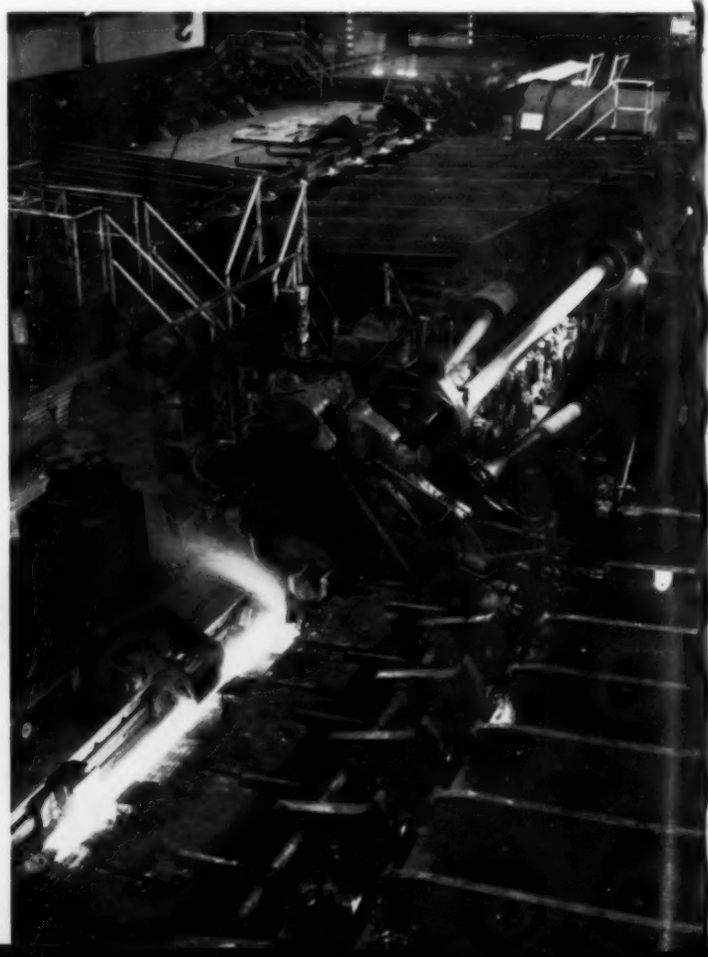


Figure 7 — A tube is clamped ready for the start of the rolling cycle.



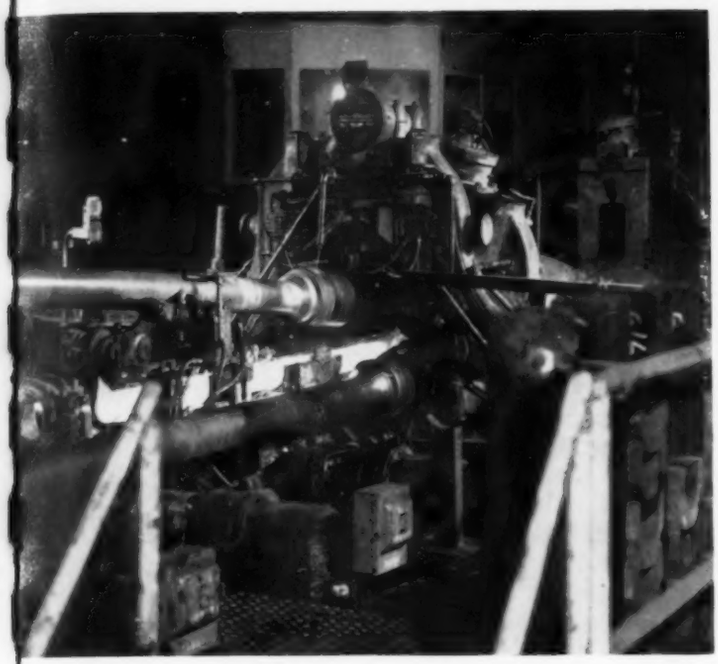


Figure 8 — Elongated tube is leaving the outlet of the mill.

Figure 7 is a somewhat more close-up view of the same operation taken from the opposite side of the inlet from Figure 6. Figure 8 is taken at the outlet of the mill.

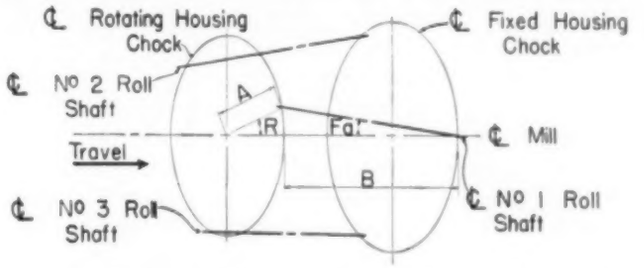
CALCULATING THE SETUP OF THE MILL

As in calculating the setup for any seamless mill, the operator of the elongator must start at the finished product he desires to produce and then work backward through his various units to the solid billet. Due consideration must be given to the amount of sink which will be taken, the amount of inlet contact desired on the elongator roll, the height of the roll hump, the size increments of the mandrel bars available, the expansion characteristics of the piercer in respect to the section being produced, and the billet or tube round size available.

At our plant in Canton, we aim for approximately ¼ to ⅜ in. sink of the elongated shell. With due allowance for the natural expansion characteristics of the mill, this desired sink will dictate the choice of an elongator mandrel bar approximately $^{3}/_{16}$ to $^{5}/_{16}$ in. larger than the finished inside diameter. Our mandrels are available in ⅛-in. increments from 1¾ to 4⅜-in. inclusive. Our rolls are turned with a 0.250-in. hump and we aim for an inlet contact of approximately 3 in. ahead of the hump. These factors of inlet contact and hump height in our case mean that we are aiming for an outside diameter reduction on the pierced shell of about $1^{3}/_{16}$ in. The humps of the rolls account for ½ in. of this reduction and the balance is taken up by the converging inlet cone at the rate of 0.104 in. per in. of roll contact. Wall reduction of the shell as produced off the piercer is normally somewhat less than the hump height of 0.250 in. All of the foregoing factors taken together indicate the desired pierced section for any given finished section produced through the elongator. Piercer practice and settings are sufficiently common knowledge that the writer will not discuss the production of the desired pierced shell. Where we must deviate from the desired conditions due to some factor, such as the absence of the desired tube round size, the necessary variation is most usually taken up in the amount of sink given the elongated tube. Variation is also taken care of by permitting the inlet contact on the elongator roll to vary between 1½ and 4⅜ in.

Consideration of the elongator feed angle and roll speed to be used for any given situation should take into account the type of steel being rolled and the section size being produced. Low feed angles (down to 4 degrees) and slow speeds (down to 110 rpm) are necessary in the elongation of tubes with walls as light as $^{1}/_{12}$ their outside diameter. Conversely, the heavier walled tubes may be run at feed angles as high as 9 degrees and at speeds up to 200 rpm. The more sensitive forging grades of steel also require low feed angles and slower speeds than the more ductile grades.

It might be well at this point to explain our concept of feed angle as it applies to the elongator. We consider the feed angle on an elongator to be the angular deflection of the centerline of the roll shafts from the working centerline of the mill. For any given degree



A= The Distance From The ℄ Of The Mill To The ℄ Of The Rotating Housing Chock

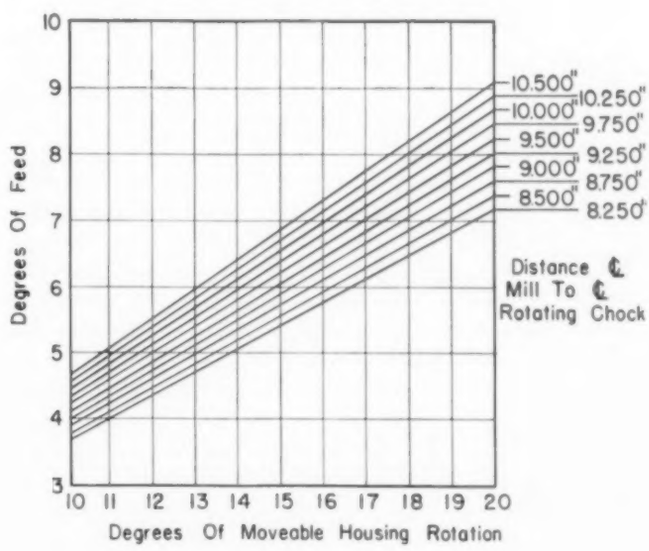
B= The Distance From The ℄ Of The Fixed To The ℄ Of The Rotating Housing Chock

R= Degrees Rotation Of The Movable Housing

$$\text{Tan } Fa = \frac{A \sin R}{B}$$

Figure 9 — Proper rotation of mill housing is necessary to obtain the correct feed angle.

Figure 10 — Feed angle chart.



of rotation of the movable housing, the feed angle of the mill is influenced by variation of either or both roll diameter and gorge setting. Therefore, in order to compensate for variation in roll diameters and gorge settings on the mill, the proper rotation of the mill housing is essential in order to obtain the desired feed angle. This desired rotation is obtained from the formula shown in Figure 9 for calculating feed angle, as follows:

$\tan fa = \frac{A \times \sin R}{B}$, where A = the distance from the centerline of the mill to the centerline of the rotating housing chock; R=degrees rotation of the movable housing; and B = the distance from the centerline of the fixed to the centerline of the rotating housing chocks. This feed angle formula is in turn the basis for the construction of our feed angle chart which is shown in Figure 10.

In utilizing this chart to obtain any desired feed angle, it is only necessary to know the distance from the centerline of the mill to the centerline of the rotating chock for the gorge setting in question. To obtain this figure, we add the roll diameter at the top of the hump to the gorge size at this same position and divide this sum by two—then subtract from this a correction factor of 0.635 in. to allow for the displacement of the center of the rotating chock due to the 3 degree conic angle of the mill. Once this centerline distance is known, it is simple to follow the proper diagonal line of the chart to the desired feed angle of the ordinate line and then drop down to the abscissa to pick up the correct degree of rotation. We are thus provided with a convenient method of obtaining any desired feed angle setting regardless of roll diameter or gorge variation.

MANDREL BAR PRACTICE

We now come to a consideration of the method of mandrel bar use on the elongator. The first mills were designed to use a full or free-floating mandrel; and for certain applications, this method is still preferable. In fact, most of the later elongator installations have been equipped for the use of free-floating bars. However, certain limitations in the operating characteristics of the mill, such as hard extraction of the mandrels on very heavy wall sections, metal distortion, and surface defects caused by the inertia imposed by large diameter heavy mandrels on relatively light-wall sections, have dictated a change in the mandrel bar practice. There are now available three separate and distinct methods of mandrel bar practice for use on the Assel elongator and these are described as follows:

1. *Full-floating mandrel:*

In this method of rolling, the mandrel bar is threaded through the pierced billet for a preset distance, after which the tube and mandrel are moved into the mill. The tube and mandrel move through the mill together and the mandrel is then removed from the elongated tube by means of an extractor. This method is the least complicated of all the mandrel bar practices and is favored when using small mandrels on relatively light-walled sections.

A more detailed description of the full-floating mandrel bar follows and is illustrated by Figure 11.

Certain basic equipment is common to all the modern mills and is employed by all three mandrel rolling practices. There is a mandrel thrust block which is pulled forward or reverse on the mill inlet table by chains over a pair of outside sprockets. The mandrel drive sprockets are connected through gearing to two 75-hp motors and two 75-kw generators connected in sandwich series. Also required is a billet pusher which is pulled forward or reverse on the inlet table by chains over a pair of inside sprockets. The pusher drive sprockets are connected through gearing to one 75-hp motor and one 75-kw generator.

Beginning a cycle for the free-floating mandrel practice, both billet pusher and mandrel thrust block are in their back positions ready to receive a pierced billet and a mandrel respectively, as in "A" of Figure 11.

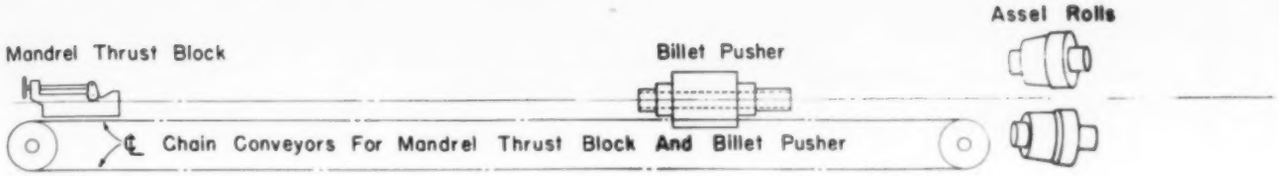
The operator presses a button which kicks one mandrel from the mandrel tank skids into guide trough in front of the thrust block. A prethread button is then pressed and the mandrel is threaded to a point where the tip just protrudes through the billet pusher. Here the thrust block is stopped by a hatchway limit switch which is adjustable in its location according to the billet length. While this prethreading is taking place the operator kicks in and clamps a pierced billet in the inlet table between the billet pusher and the mill proper as shown by "B" of Figure 11.

After clamping, the operator jogs the mandrel forward to determine safe clearance through the billet and then advances the thrust block master switch to "Run" position. From this point, the mandrel thrust block is in a fully automatic cycle to complete threading and immediate high speed return ready to begin another cycle.

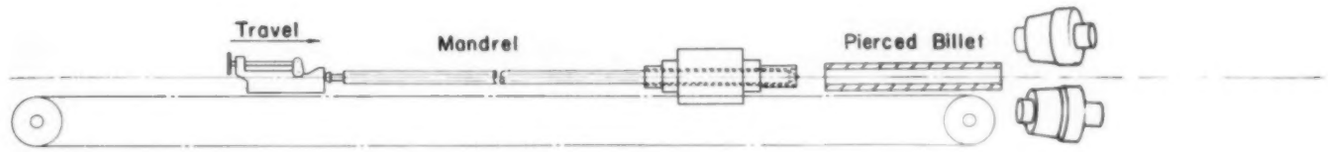
Just as the mandrel threading operation is completed, the billet clamp is released and the pusher operation is begun. The pusher operation is manual from a master switch providing two speeds forward and two reverse. "High Speed Forward" is used to bring the mandrel threaded billet near the mill rolls and "Low Speed Forward" when engaging the rolls. The operator may then follow forward to prevent whipping of the mandrel by using the pusher as a mandrel guide. Relative position of the various units at the beginning of the rolling cycle is illustrated by "C" of Figure 11.

At or near the completion of the rolling, the operator pulls the pusher master switch into "High Speed Reverse," with "Reverse Slowdown" and "Stop" provided by limit switches. The inlet table is now cleared and ready to receive another mandrel and pierced billet in preparation for repeating the cycle.

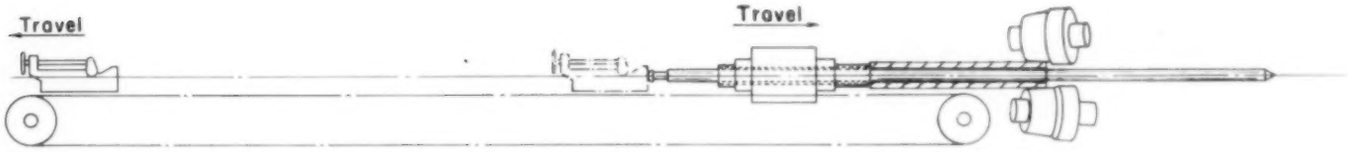
When the load leaves the mill motor, the outlet table rolls rise and the elongated tube and mandrel are conveyed to a kickoff, onto skids and then roll onto the chain stripper inlet table. These inlet table rollers allow a brief steadying time and then convey the rear of the mandrel through a stripping plate into the chain stripper. In operation and appearance, this chain stripper is suggestive of a cold drawbench. On passing through the stripper plate, which has a hole large enough to pass only the mandrel, the mandrel engages a limit switch starting the stripper. A yoke mounted between two drawbench chains engages a notch in the mandrel and continues a cycle of acceleration, slowdown, and stop. This pulls the tube against the stripper plate and withdraws the mandrel from the tube.



"A" Start Up



"B" Mandrel In Pre-Threaded Position Prior To Threading Through Pierced Billet



"C" Start Of Rolling Cycle. Mandrel Thrust Block Has Returned To Start Up Position

Figure 11 — Schematic shows operation of mill with free floating mandrel.

During this stripping cycle, the stripper inlet rollers were stopped, ready for the next tube, and at the completion of stripping the tube is kicked out to further processing.

When the chain stripper enters its next cycle, the first mandrel passes rearward off the chain saddles onto a return conveyor and is kicked into a cooling tank. A star wheel in the tank advances one pocket each time a mandrel is kicked into the tank, and thus carries each mandrel through cooling and delivers them back to the inlet skids of the mandrel thrust block

The mandrel bar chain stripper is powered by a 100-hp, dc motor with constant voltage control providing timed acceleration, armature shunt low speed, and dynamic braking.

2. *Retracting mandrel:*

Expressed in its simplest terms, this practice removes the mandrel bar from the tube during the rolling operation so that the stripping of the mandrel bar is coincident with the completion of the rolling cycle.

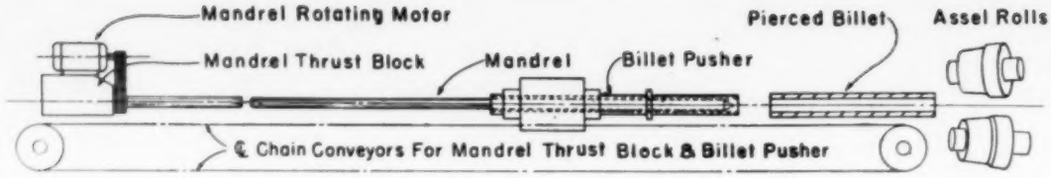
The use of this method requires the same thrust block and billet pushing equipment that has already been described. The distinction here is that a single captive mandrel bar is attached to the mandrel bar thrust block which is equipped for mandrel bar rotation.

At the start of the operating cycle, the mandrel bar and pusher are in their back position as shown in "A" of Figure 12. A pierced billet has been kicked into the inlet guides and clamped in position for threading.

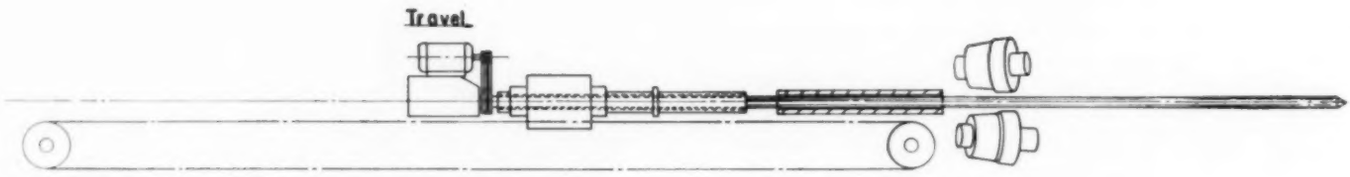
The operator pushes the "Clamp" button and the clamp comes down on the pierced billet and holds it for threading. The operator jogs the mandrel bar forward with the master switch until the mandrel enters the pierced billet. If there is no obstruction to this point, the operator puts the master switch into the "Run Forward" position which starts the automatic cycle. The mandrel accelerates and runs forward at 96 in. per sec until it actuates a slowdown cam. The mandrel bar slows down and runs at a slow speed for a distance of approximately 12 in. until stopped by a hatchway final stop limit switch. The mandrel bar has now been threaded through the pierced billet and extends beyond the mill roll humps for 14 ft as shown in "B" of Figure 12.

The mandrel rotate motor which is mounted on top of the mandrel thrust block starts when the master switch is put into the "Run Forward" position and remains in rotation until timed out by a time relay which runs until shortly after the pierced billet enters the elongator rolls.

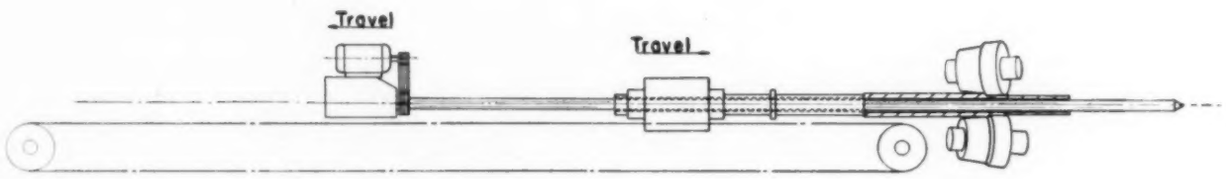
The mandrel slowdown cam switch starts the pusher and operates the solenoid valve to open the tube clamp. The pusher accelerates to 34 in. per sec and then operates a limit switch which transfers the speed control



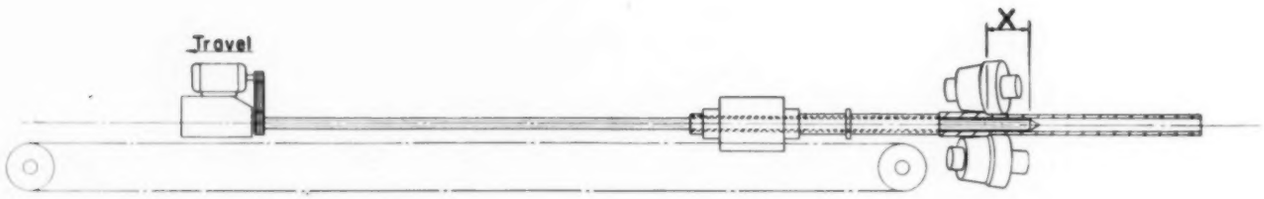
"A" Start Up



"B" Mandrel At Full Threaded Position. Billet Pusher Ready To Start Forward



"C" Positioning Cycle With Mandrel Retracting. Pusher Follows Pierced Billet Into Mill



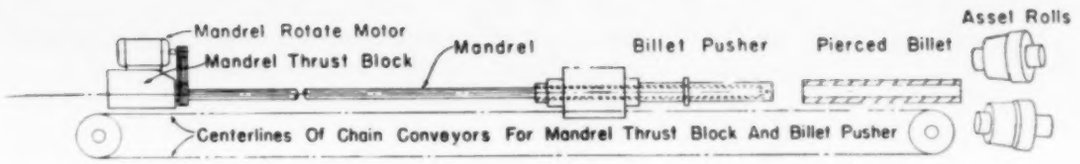
"D" End Of The Positioning Cycle. Start Of Rolling Through "X" Distance

Figure 12 — Schematic shows operation of mill with retracting mandrel.

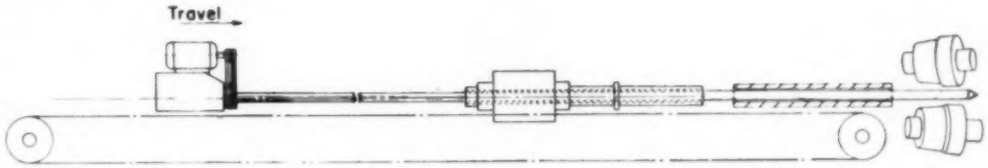
of the pusher to a rheostat mounted on the operator's desk. The positioning cycle is entered when the pusher trips the positioning limit switch which has been preset according to the pierced billet length. The positioning cycle should be entered just before the pierced billet enters the mill rolls. As soon as the mill starts rolling, the load relay on the main drive transfers the pusher rotating regulator from a voltage regulator to a current regulator and the constant push is controlled by two tension regulating rheostats mounted in the control room.

The positioning cycle is the period during which the pusher is pushing the pierced billet into the elongator rolls and the mandrel thrust block is retracting the mandrel through the tube, as is illustrated by "C" of Figure 12. Prior to the positioning cycle, the mandrel is extended a preset distance of 14 ft beyond the mill roll humps. The length of the ingoing pierced shell may vary anywhere between 6 and 16 ft. The object of the positioning cycle is to retract the mandrel at a *per cent* travel which is equal to the pusher *per cent* travel to a preset point known as the "X" distance. The "X" distance is a rheostat controlled distance of 3 to 36 in., measured from the roll humps to the forward end of the mandrel bar and is reached regardless of the length of the pierced billet when the pusher has completed its forward cycle. The condition at this point is illustrated by "D" of Figure 12.

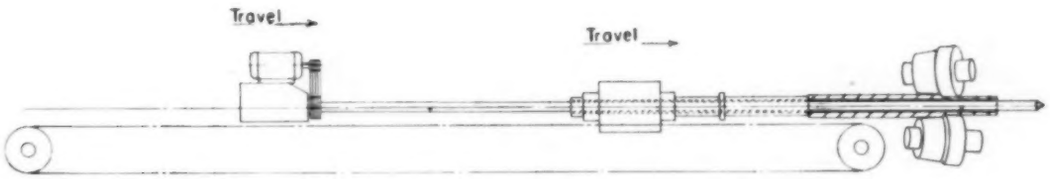
The basis of the positioning cycle consists of two rheostats, one geared to the pusher drive and the other



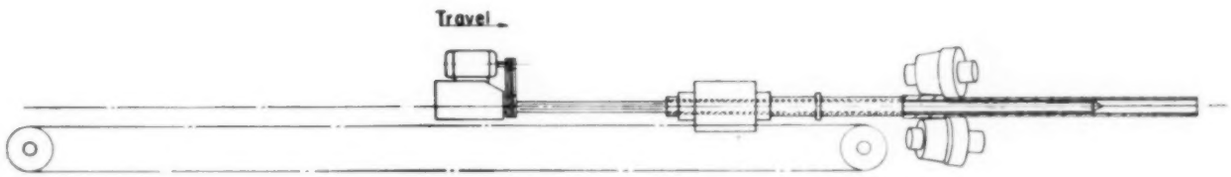
"A" Start Up



"B" Mandrel At Threaded Position. Billet Pusher Ready To Start Forward



"C" Start Of The Rolling Operation. Mandrel And Pusher Both Moving In Direction Of Rolling



"D" Pusher At End Of Forward Travel. Mandrel Continues Forward Travel To Completion Of Rolling

Figure 13 — Schematic shows operation of mill with semi-floating mandrel.

to the mandrel thrust block drive. The two rheostats are electrically connected in series through positioning fields on first stage magnetic amplifiers. During the positioning cycle, if the two drives tend to get out of step, the rheostats through the magnetic amplifiers force the two drives to stay together so that when the pusher has completed its forward cycle, the mandrel has retracted to the preset "X" distance as previously noted.

When the positioning cycle has been completed, there still remains approximately 10 in. of pierced shell to elongate. At this time, the pusher stops for the purpose of mandrel guiding only until a preset time relay times out. The pusher then returns to its start-up position in voltage regulation at a speed controlled by the pusher motor field weakening rheostat mounted on the operator's control desk. Under normal operating conditions, the "X" distance is maintained at a distance of 24 in. The mandrel continues to retract through this 24 in. at a desk rheostat controlled speed so that the mandrel just withdraws as the tube leaves the mill. The mandrel then returns to its start-up position at high speed. The elongated tube is conveyed away from the mill to further processing by outlet conveyor rolls. This completes the entire rolling cycle and the operation is ready to repeat.

3. *Semi-floating mandrel:*

This method of rolling is a compromise between the free-floating mandrel and the retracting mandrel practices. With this method, the mandrel is restrained but is permitted to move forward with the work piece at a differential speed, and then is stripped out of the elongated tube right after the completion of the rolling operation.

The use of this method requires the same mandrel and pusher equipment as for the retracting mandrel. The necessary electrical changes are made through a type "W" selector switch in the main control room. At the start of the operating cycle, the mandrel bar and

pusher are in their back positions the same as for the start of the retracting mandrel method of operation. A pierced billet is kicked into the inlet guides in position for threading and the condition of the mill is illustrated by "A" of Figure 13.

The operator pushes the "Clamp" button and the clamp comes down on the pierced billet and holds it for threading. The operator jogs the mandrel bar forward until the mandrel enters the pierced billet and then puts the master switch into the "Run Forward" position which starts the automatic cycle. The mandrel accelerates and runs forward at 96 in. per sec until the front end of the mandrel bar is at a point approximately 15 in. beyond the roll humps, as shown by "B" of Figure 13. A cam which has been actuated at this point opens the tube clamp, starts the pusher forward, and transfers the control of the forward speed of the mandrel to a rheostat on the operator's control desk. The mandrel speed forward is selected relative to the billet speed forward and is of a value less than the billet travel.

The mandrel rotate motor starts when the master switch is put in the "Run Forward" position and remains in rotation until timed out by a time relay after the load goes on the main drive motor.

After the tube clamp has been opened, the pusher accelerates to 34 in. per sec until it operates a limit switch which has been preset to the length of the pierced billet. This limit switch transfers the speed control of the pusher to a rheostat on the operator's desk. The pierced billet is now inserted into the mill and the mandrel and pusher move forward in the same direction as the tube travels. ("C" of Figure 13).

As soon as the pierced billet enters the elongator rolls, the load relay on the main drive motor transfers the pusher rotating regulator from a voltage regulator to a current regulator and the pusher maintains a constant push against the billet. This push is preset on the tension adjusting rheostats that were mentioned in the retracting mandrel operation. The pusher maintains a constant push against the billet until making contact with its final stop limit switch. At this time, there is still approximately 10 in. of pierced billet to be elongated, as shown by "D" of Figure 13. The pusher remains at its final stop position until a preset time relay times out and then returns to its starting position in the same manner as when rolling with the retracting mandrel.

The mandrel, meanwhile, continues to move forward with the elongating tube until the main drive load relay drops out. At this time, the tube is stripped off the mandrel by means of a pinch roll and the outlet table dragout rolls. The mandrel then returns to its starting point at high speed and the operation is ready to repeat. The maximum amount of mandrel bar surface which can be rolled upon in this operation is approximately 10 ft.

In considering the relative merits of the three methods of mandrel bar practice which have been described, mention has already been made of the simplicity of the free-floating mandrel as well as its superiority in the production of the lighter walled sections. The retracting mandrel's greatest asset is the ability to produce extremely heavy-walled sections with ease. The semi-floating mandrel is chiefly useful in the production of light-walled sections in a mill which is not equipped for full-floating mandrels or when it is not desired to take the mill time to make the change-over from retracting to free-floating bars.

COMMON CHARACTERISTICS OF THE MILL

No description of the Assel elongator would be complete without mention of what might be termed the mill's individual characteristics. These are as follows: (1) eccentricity correction; (2) twist; (3) feed efficiency; and (4) optimum section; plus many other advantages.

1. *Eccentricity correction:*

Experimental studies with machined shells of known eccentricity entering the elongator have proven a correction in this known eccentricity of from slightly more than $\frac{1}{2}$ to almost $\frac{2}{3}$. It should be emphasized that this does not refer to a lineal correction, but to the percentage of wall variation in the outgoing or elongated section compared to the ingoing shell. The greatest amount of correction is obtained in the sections with the largest entering eccentricity and the converse is true of the entering sections with the least amounts of eccentricity. The correction in eccentricity just referred to is with a normal mill setting, with the incoming shell making contact with the elongator rolls at a point about 3 in. ahead of the roll humps.

A still greater correction in eccentricity, whereby almost $\frac{3}{4}$ of the entering wall variation may be removed, can be obtained by increasing the roll contact on the work piece ahead of the roll humps to 4 in. or slightly more. The eccentricity correction inherent in the elongator in combination with the comparatively small sinking mill reductions which are normally taken, enables the mill to roll to a narrower spread in wall variation than can be produced on the conventional high or automatic type of mill.

2. *Twist:*

As in all cross-rolling mills, there is a tendency in the elongator toward twisting the fibers of the work piece as it passes through the mill. With normal mill settings, the following generalities pertaining to twist may be quoted:

1. Twist increases as the mill feed angle is lowered.
2. Twist increases as the roll rpm is increased.
3. Twist increases as the inlet contact on the roll is increased.

Experimental studies of twist in the Timken Company elongators have shown an angularity varying from 8 to 37 degrees, as influenced by the three factors noted above. By way of explanation, it should be mentioned that this experimental work was done with pierced shells which were cooled and then had a slot $\frac{1}{32}$ in. wide x $\frac{1}{16}$ in. deep machined along their entire longitudinal axis. These shells were then reheated, elongated using varied mill settings, and the distortion of this machined seam was taken as a measure of twist.

3. *Feed efficiency:*

The basis for the calculation of feed efficiency in the mill is taken on the diameter of the elongator roll at the tangent point at the top of the roll hump. Using this point as a base for the calculation of the theoretical mill delivery feed, the average feed efficiency of

these mills is about 80 per cent for the retracting mandrel method of rolling, 85 per cent for the semi-floating mandrel, and 90 to 95 per cent for the free-floating mandrel method of rolling. Speaking in terms of lineal outlet delivery, a range of from 8 to 21 in. per sec is common.

4. *Optimum section:*

Our last main consideration of the mill's characteristics deals with the matter of optimum section. By this is meant the range of sectional dimensions which the mill will produce best. Using the relationship of outside diameter to wall thickness and expressing this relationship as a direct ratio, the modern elongator as described in this paper will produce seamless tubing of superior dimensional control in outside diameter to wall thickness ratios to a maximum of 12:1 at the elongator gorge. In the lower ratios or heavier walls, the limit is governed by the availability of the smallest mandrels and/or the ability to sink the resultant product of the mill. Generally speaking, the Assel elongator is not a light-wall mill as used in this country. This does not preclude the dressing of special contoured rolls to produce a lighter than standard section. However, these special contoured light-wall rolls require a very steep roll hump angle and are not suited to the production of our heavier walled tubing. Specifically, the steep angled hump or light-wall roll marks the outside diameter of the heavier sections. Since the Timken Company is interested mainly in the relatively heavier sections for mechanical applications, we confine our elongators to these sections and produce the lighter items on our high mill.

DISCUSSION

PRESENTED BY

A. B. CAPRON, Chief Engineer, Tubular Products Division, Babcock and Wilcox Co., Beaver Falls, Pa.

CHARLES E. SNEE, General Foreman, Assel Mill, The Timken Roller Bearing Co., Steel and Tube Division, Canton, Ohio.

Member: Mr. Chairman, we are using practically the same procedures as Mr. Snee mentioned. I would like to ask a question concerning mandrel bar lubrication, which is a problem in some of these mills. I would like to know which style of lubrication is being used in each of the three processes?

A. B. Capron: Mr. Snee's paper makes the operation of an Assel mill appear to be a relatively simple process, but those of us who have seen it being set up and in production realize that its present state of perfection is only because a lot of hard work, brains, and "know-how" have been applied to the job. The mechanization and automation which has been built into the unit has resulted in not only the ability to produce a better tube but to do it with less manpower.

Those of us in the specialty tubing business always try to get the widest possible range of sizes, walls and lengths out of any production equipment we install, and although I realize that Timken is primarily interested in heavy-wall mechanical tubing, I would like to know the reasons for the 12 to 1 diameter-to-wall ratio you state as a maximum. A 3-in. diam x 0.250-in. wall tube meets the maximum ratio and would presumably be the lightest wall that can be made in that diameter. What happens if you attempt to make 3-in. x 0.220-in. wall or 0.180-in. wall, assuming of course that your pierced hollow is of the proper wall thickness to be reduced to these walls by the rolls in the Assel mill?

Mr. Snee's description of the three different types of mandrel bar practices was quite clear as to the methods of operation, but I would like to know more about the limitations of each method. I would think that the use of the retracting mandrel would result in a greater production in pieces per hour than with the semi-floating mandrel because of the time saved in stripping. Can this type mandrel be used for the full range or is there a limitation in diameter-to-wall ratio when using the retracting mandrel? In your description of the retracting mandrel operation, you stated that the billet pusher continued to push the pierced hollow into the Assel mill for the full length of its travel, even though the rolls were gripping the hollow and pulling it ahead. Why is it necessary to push the hollow after it is gripped by the rolls?

Many of us in this field produce pressure tubing as well as mechanical tubing in the diameter-to-wall ratio range of the Assel mill, and I would like to know your opinion of the outside and inside diameter surfaces of an Assel mill tube when put up against the specifications for a pressure tube. Have the rings which were visible on tubes made in the early stages of development been eliminated so that an eagle-eyed pressure tube inspector would pass them?

The Assel mill is one of the few innovations which have been made in tube producing methods in the last 25 years and this paper explains its operation very clearly. I am sure that Walter Assel, Ross McLaren and you have spent a lot of long days and nights developing the mill to the state of perfection it now enjoys.

Charles E. Snee: In response to the question on mandrel bar lubrication, we use common table salt (NaCl) and soda ash (Na_2Co_3) as a means of lubrication. These lubricants were chosen after considerable experimentation with a wide range of lubricants, including organic ones. When we are employing the full floating mandrel bar method of rolling, the lubricant is picked up by the mandrel bar as it passes through the mandrel cooling tank. The tank coolant is a water solution of three per cent each of the salt and soda ash. When semi-floating or retracting the mandrel bar, we use an air injector to deposit 1½ to 2 ounces of the powders combined —two parts of salt to one part of soda ash— in the front end of the pierced tube just before the insertion of the mandrel bar.

Mr. Capron raises the question of why we put a 12 to 1 limit on the maximum ratio. The limiting factor is the ability of the mill to produce superior tubing economically. When you go lighter than 12 to 1, it is not a question of the elongator being able to produce the section, but that the resultant product is not enough better than the product of our high mill that it pays to take the added time required in the elongator. We can roll and have rolled on our Wooster elongator,

walls as light as ⅛ in. The reason for using the Wooster mill is that this mill is equipped for full floating the mandrel bars, and it is easier to produce a light section on a full floating setup. However, due to the fact that the mill feed angle must be drastically reduced even there, the elongating times become excessive. On the ⅛ in. wall section mentioned, which was roughly 2¼ in. outside diam, it required 47 seconds to elongate a 13 or 14-ft tube. This time is, of course, prohibitive and cannot compete against the production rate of the high mill.

To explain this matter a little further, it all arises due to the fact that in the cross rolling of the work through the mill, the work tends to balloon away from the roll humps more and more as the wall becomes lighter and lighter. This ballooning will produce a back end triangulated condition or "fish-tail" in the light sections, which will then stick in the outlet of the mill. The remedy is to reduce the feed angle to where the mill will deliver, but this, in turn, raises the elongating time.

In reply to the question on the limitations of each method, we have pretty well established that on the basis of the ratio of outside diam to wall at the gorge of the elongator. We prefer to roll semi-float whenever we can, as this method is actually faster than retracting. The time lost in stripping the tube from the mandrel bar is more than made up by the added feed efficiency of the mill. We are able to semi-float at outside diam to wall ratios of 7½ to 1 and lighter. Where the walls are heavier than at 7½ to 1, they will not balloon off the mandrel bar sufficiently for easy stripping, and we have to retract the mandrel on these heavier sections.

The question of why we push toward the mill after the roll has gripped the work must be answered in the requirements of the electrical control circuits. The billet pusher on these automatic elongators with their retracting or semi-floating mandrels is the intelligence for the electrical circuits. It is, therefore, necessary to keep your pusher up the back end of the tube being elongated in order to balance out these electrical circuits, so that, at the end of the rolling operation, you are at the proper location with your mandrel bar.

As respects the question on pressure tube applications, we do not know at this time what the reaction of the pressure tube inspectors might be. We intend to line up an experimental order in the future and obtain their opinion. The product of the elongator will still have the characteristic inside diameter ring which many of you have seen if you are familiar with Assel mill tubing. This ringed condition is only a few thousandths deep, but in looking through the inside diameter of the tube, it looks much worse.

I should add that this matter of pressure tube application, as well as other problems on these mills, is subject to continuing development and experimental work in the future.

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1010 Empire Building Pittsburgh 22, Pa.

Contributions to Arc Furnace Operations

By L. A. WYND

Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.

▲ CONTRIBUTIONS to arc furnace operations come from many sources. Corporations have contributed large amounts of money toward it. Many individuals have contributed engineering skill. Ingenious methods have been devised by persons who are neither engineers nor mechanics. Persons familiar with arc furnace operations willingly pay tribute to anyone with an idea which decreases kwhr consumption, improves tons per hour, decreases electrode consumption, lowers brick costs, or any of the worthwhile contributions which improve the art of operating one of the most fascinating and complex units used in the steel industry.

At this point it seems apropos to briefly mention the important part played in this advancement by a number of papers dealing with optimum current control. Quite naturally, the majority of these contributions have appeared in the AISE's own publication *The Iron & Steel Engineer*. Application by arc furnace operators of fundamental principles outlined in these papers has been so beneficial that it is now an impossible task to give accurate figures of the tremendous sums that they have saved the steel industry in general.

The purpose of this paper is to describe a modern arc furnace installation and to describe uses its operators have made of some of the important contributions to operating efficiency.

Republic Steel Corporation has one of its eight steel producing centers in Chicago. This unit is a completely integrated alloy steel plant bordering the Calumet river. Placed in operation in 1943, with blast furnace, open hearths, electric furnaces and rolling mills, it soon became an important unit in the Nation's economy.

The original arc furnace layout consisted of nine Heroult type units, supplied by a total of 108,000 kva in transformer capacity. Present transformer capacity is 148,000 kva due to larger transformers on five of the furnaces. Seven of this group are side charged, two are top charged.

Figure 1 is a schematic one-line diagram of the basic feeder circuits for this plant. It shows service lines, transformers, arc furnace ring bus, feeder lines, mill feeders and busses. The three main transformers are each 3-phase, 3-winding, 60-cycle, 33,000-kva normal, 42,000-kva emergency rating.

Primary voltage is 66 kv. Low voltage is 12 kv, and tertiary 6.6 kv. The low voltage 12 kv winding supplies the arc furnace load, and the 6.6 kv tertiary winding supplies the mill load. Primary winding is delta. Low voltage and tertiary are "Y" with grounded neutral.

. . . . at Republic's electric furnace plant at Chicago, production has been increased by 70 per cent as a result of a number of improvements to the furnace units, chief of which are top charging, optimum current control, and increased secondary voltage . . . .

Inherently bad load conditions prevail in any large concentration of arc furnaces. To offset the effect of this, the main transformers were designed with higher than normal impedances between the three windings. These impedance values are as follows in per cent:

High voltage to low voltage at 33,000 kva=10.1
High voltage to tertiary at 33,000 kva=17.9
Low voltage to tertiary at 33,000 kva=34.5

This combination of transformer impedances results in a 3.25 per cent negative value for the equivalent reactance of the high voltage winding, which corrects line drop within these limits. This feature has successfully eliminated serious voltage dips throughout the plant.

The 12-kv feeder and tie breakers in the arc furnace ring bus are oil-type, 1,500,000-kva interrupting capacity. Individual back-up breakers for each of the nine arc furnaces are oil at one million volt interrupting capacity. The circuit breakers following the back-up breakers are air, rated 250,000 volt interrupting capacity. These breakers are 15 kv with magnetic arc spinning blow-outs. No compressed air is used. Their choice was made to decrease high maintenance costs and other undesirable features of conventional oil circuit breakers in common use on arc furnaces prior to 1942. These breakers open and close each time a tap change is made, and average 3000 operations per month per furnace. Selective relaying protects this breaker whenever overload approaches its rating. When an arc furnace short, due to scrap cave-in or other cause, exceeds 180,000

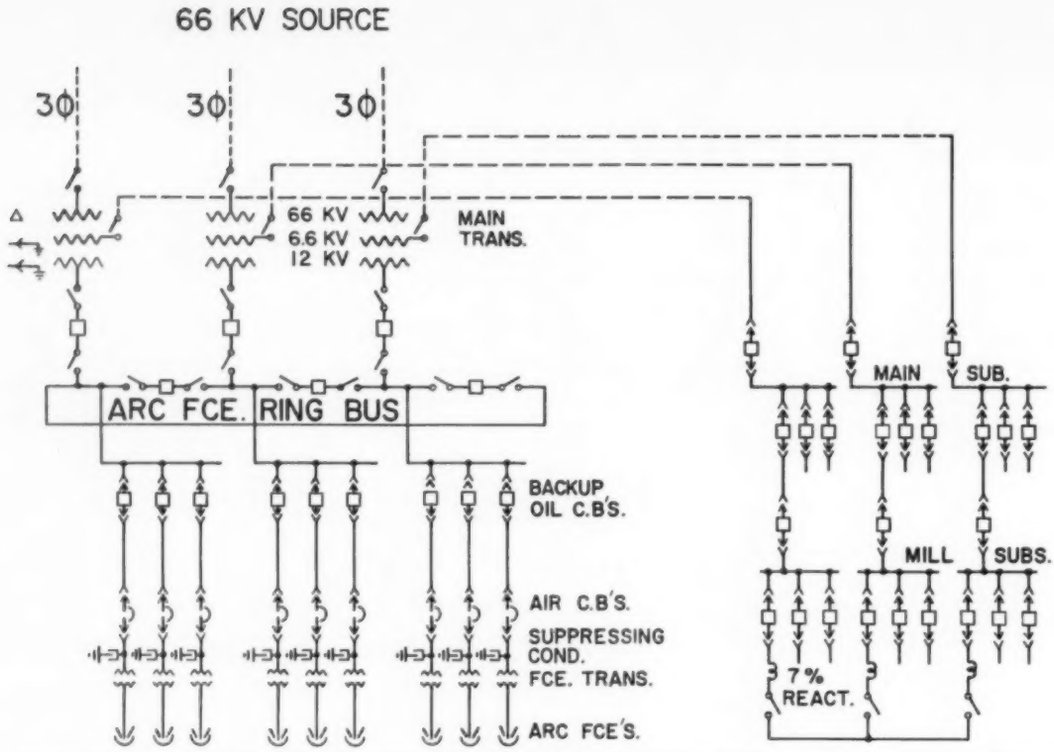


Figure 1 — Schematic one-line diagram shows basic feeder circuit for the electric furnace plant.

kva, a relay locks in the air circuit breaker and trips the back-up oil circuit breaker at the main sub-station. Overloads below 180,000 kva are cleared by the air circuit breaker.

Figure 2 shows the arrangement of the arc furnace air circuit breaker in the transformer vault. Cables come in from the main sub-station under the air circuit breaker up through it to the transformer above. Suppressing condensers of 0.25 microfarad capacity are attached to the transformer primaries at the top of the breaker. The nine transformer vaults are supplied with air under pressure which has been cleaned by a combination oil and static filter.

Each upper and lower transformer vault is equipped with piping so that either or both may be flooded with CO_2. One ⅜-ton mobile extinguisher is available for

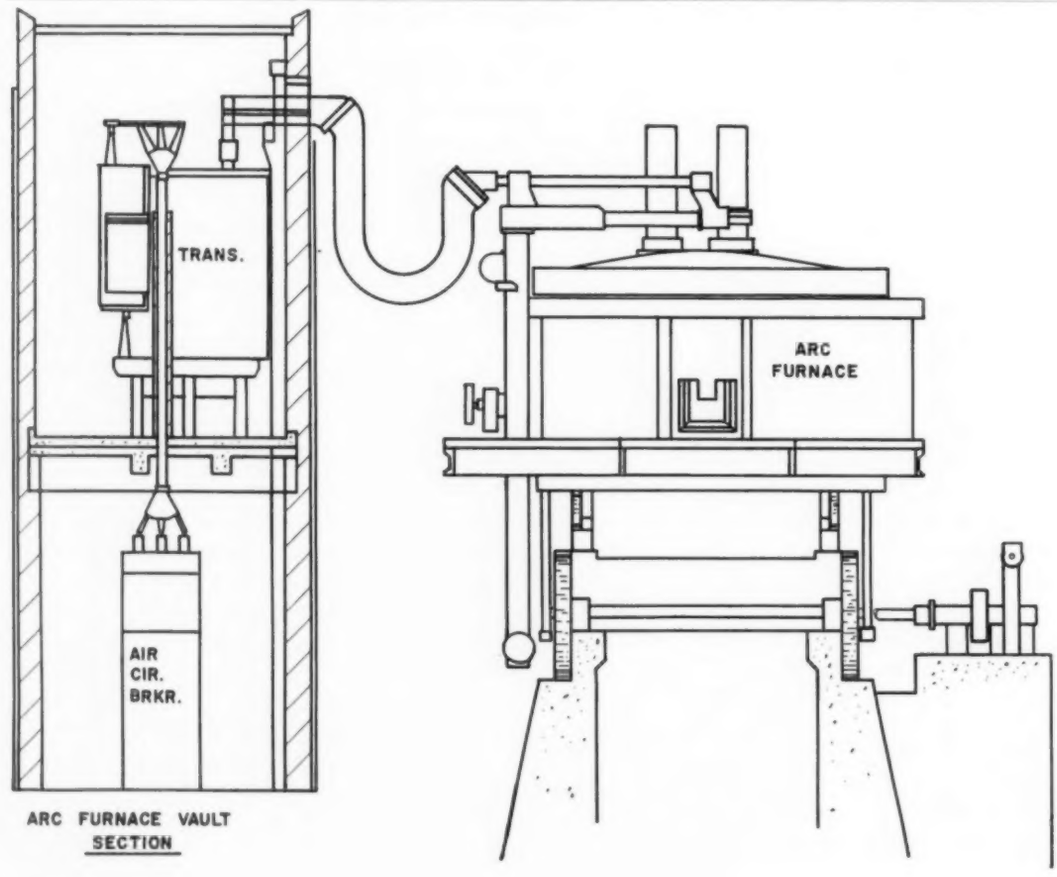


Figure 2 — Arrangement of circuit breakers in transformer vault is shown by schematic.

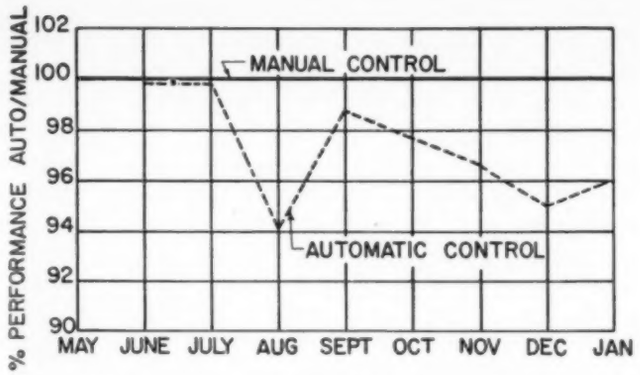


Figure 3 — Index of performance curves show ratio of kwhr per ton needed for furnace with automatic control compared with furnace on manual control on a percentage basis.

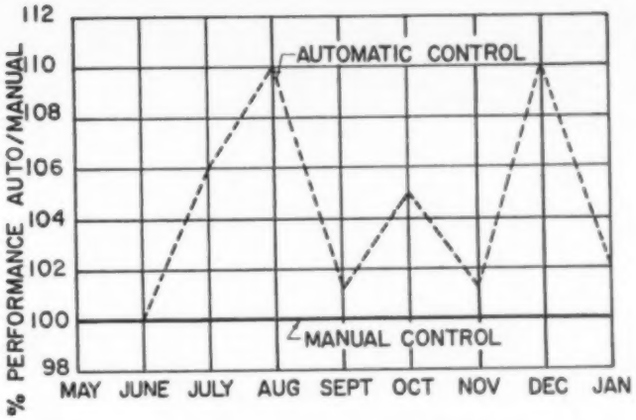


Figure 4 — Index of performance curves show tons of steel of all grades per furnace hour for furnace with automatic control versus furnace with manual control on a percentage basis.

connection to fittings on the lower outside wall of each vault.

To offset the lagging power factor of the furnace load, 44,700 hp in 0.8 leading power factor synchronous main motors were chosen for the 6.6-kv mill load section of this installation. This obviated the necessity for special synchronous condensers. During full load conditions, the following prevails:

Controlled 30-minute demand—81,000 kw
Average month power factor—0.92 lag
Energy per month—44,000,000 kwhr
Load factor 744 hr month—0.74
5-min peaks of 100,000 kw are not uncommon.

Regulation is kept within 3 per cent at the ring bus during full load conditions with all main transformer breakers and all tie breakers closed. This data does not include a demand of 11,000 kw and monthly energy block of 6,000,000 kwhr from another sub-station in an older section of the plant.

Automatic optimum current control has been in use on this group of arc furnaces for a number of years. It is used only on furnace taps No. 5, 4 and 3. Taps No. 2 and 1 are manually controlled at the discretion of the operator. Figures 3 and 4, covering a period in 1948, give a good idea of benefits accruing from this control.

With the advent of optimum settings in this shop, immediate attention had to be given to furnace transformer temperature problems. Figure 5 is a curve which was developed by one of the electrical manufacturers in conjunction with the engineering department of a midwestern steel plant which uses electrical arc furnaces exclusively. It shows the calculated temperature differential existing between transformer oil and hottest spot of the transformer primary winding. It clearly demonstrates the fallacy of operating transformers by using only the oil temperature indicator supplied with the unit.

Investigation disclosed that a device called "Hottest Spot Indicator" had been developed and was being used on a number of public utility large power transformers. Figure 6, shows thermal indicator connections. The following is an excerpt from the manufacturer's instruction sheet:

"The Hottest-Spot Dial Type Thermal Indicator is an auxiliary piece of apparatus used to indicate the temperature of the hottest spot in transformer windings. This temperature is approximately duplicated at the bulb of a standard dial type thermometer, and is read directly on the externally-located indicator dial. (A graphic meter operating on the same principle can also be used.)

"The bulb, which is made of high-resistance metal is supported in the hottest part of the transformer oil. It is connected across the secondary windings of a current transformer so that a current proportional to the load current of the main transformer passes through the bulb. From these two sources of heat the bulb attains a temperature approximately that of the transformer windings.

"The bulb is surrounded by a tube of such thickness that the difference in temperature between the bulb

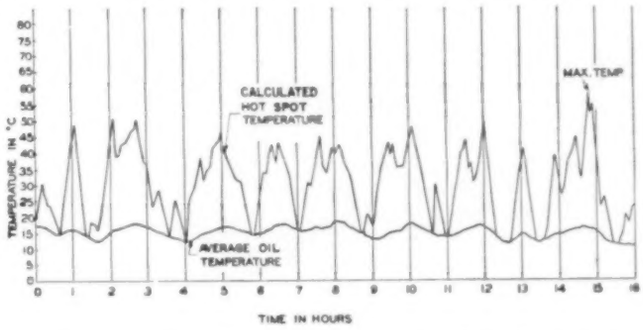
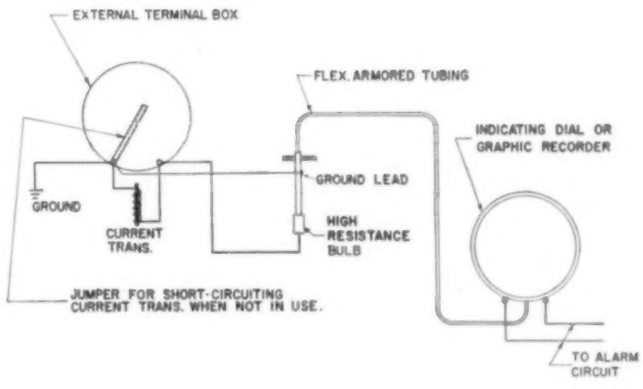


Figure 5 — Curves give arc furnace transformer temperature. Oil temperature cannot be depended on to give the hot spot temperature.

Figure 6 — Connections for thermal indicator are given by diagram.



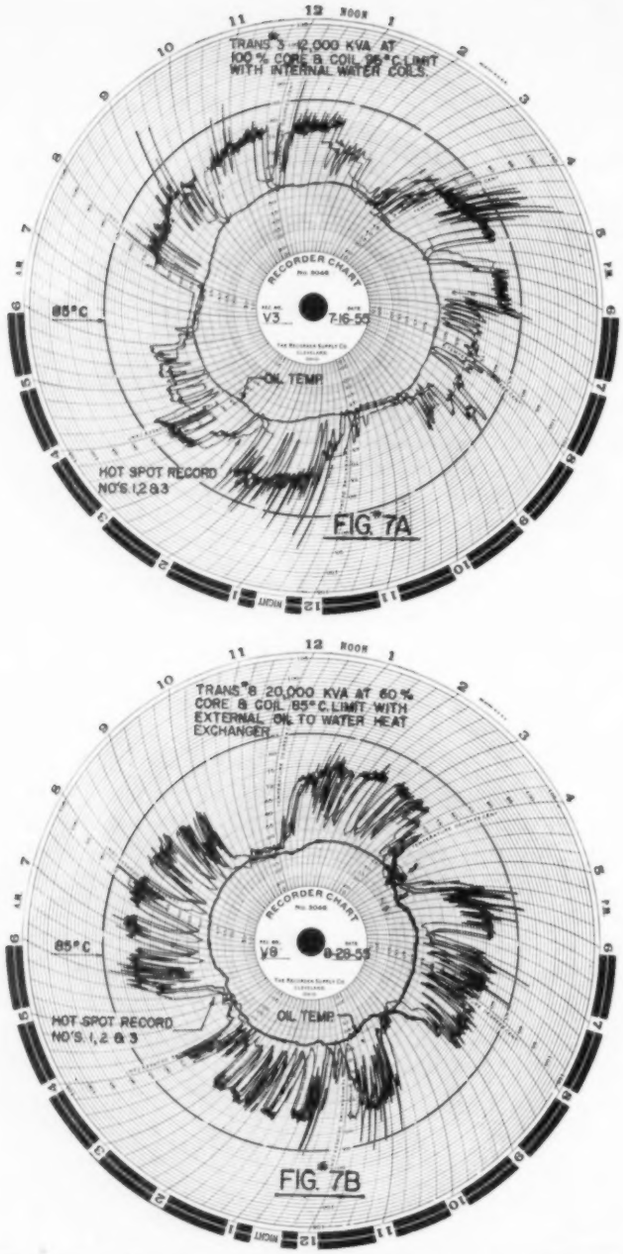


Figure 7 — Upper curves give hot spot and temperature records on 12,000-kva transformer with internal water coils and lower curve gives same data for 20,000-kva transformer with external oil-to-water heat exchanger.

and the oil is the same as that between the windings and the oil.

"*Note:* At the time of the heat test of the transformer, the adjustment of the current flowing through the bulb is checked to be sure that it produces the additional increment of heat corresponding to a conventional 10 degree allowance for the hottest parts of the windings at full load."

In practically all utility installations, a single "hottest spot" indicator is used. This practice seems to prevail whether the transformers are single or multiphase. There does not seem to be any good reason for disagreeing with this practice where power company transformers are involved. However, protection of large multiphase arc furnace transformers presents a different problem. Single phasing may occur in arc furnace operation for enough duration to build up a "hottest spot" in that part of the transformer winding supplying the load. Due to the make-up of the charge, this single phasing may occur and reoccur almost continuously on No. 5 or No. 4 tap during the first part of the breakdown.

Power input is so great during this interval that in certain transformer sections, normal capacity will be greatly exceeded for short periods. The rms value of this load can cause excessive heating and attendant damage to insulation which may not be apparent for some time. If permitted, repetitive occurrences will eventually cause serious transformer outage. A faulty contact in a tap changer will cause similar trouble in a transformer not protected with "hottest spot" indicators.

While the primary purpose of the "hottest spot" indicator is one of protection, it also has the important function of indicating whether optimum current settings are in proper relation to transformer capacity. This device actually accomplishes three important functions. It will indicate dangerous overloading, maximum safe loading, or safe but wasteful underloading.

It is the developed policy of Republic Steel Corporation to equip each arc furnace transformer with three "hottest spot" indicators. One hottest spot current transformer is placed in each leg of the delta connected secondary. This arrangement is made to prevent temperature damage to any part of the transformer winding by balanced or unbalanced load. Due to frequent tap switching of the primary from "Y" to delta, or vice versa, it is logical to place the current transformers for these indicators in the permanently closed secondary delta. This avoids a multiplicity of current transformers and complex connections. A valuable auxiliary to the "hottest spot" indicator is the 4-pen graphic recording instrument which records temperature from each indicator as well as oil temperature. Figures 7A and 7B, are reproductions of service records produced by two such instruments. These charts are actual operating records of 12,000 and 20,000-kva furnace transformers.

The use of optimum control, increase of transformer sizes from 12,000 kva at 100 per cent core and coil to 20,000 kva at 60 per cent core and coil, coupled with a swing to top charging, necessitated better transformer oil cooling. Improved methods of circulation and forced flow through well-designed heat exchangers accomplished this. Figure 8, shows oil flow and the location of visual temperature and flow indicators in the two oil circuits each transformer has. The flow indicators have an attachment which drops an annunciator target, puts on a red light, and rings a bell upon flow failure. Most causes of flow failure are due to failure of the oil pump motor or interruption of its power supply.

The above mentioned annunciator has targets for both heat exchanger pumps, each of three "hot spot" indicators, oil temperature, oil level, operation of pressure relief valves, and smoke protection signal from the air circuit breaker compartment. Demand control circuits from the main sub-station do not enter this annunciator.

Scheduled maintenance of oil is a "must" in arc furnace transformer care. This schedule must work toward detection of moisture, oxidation, and excessive

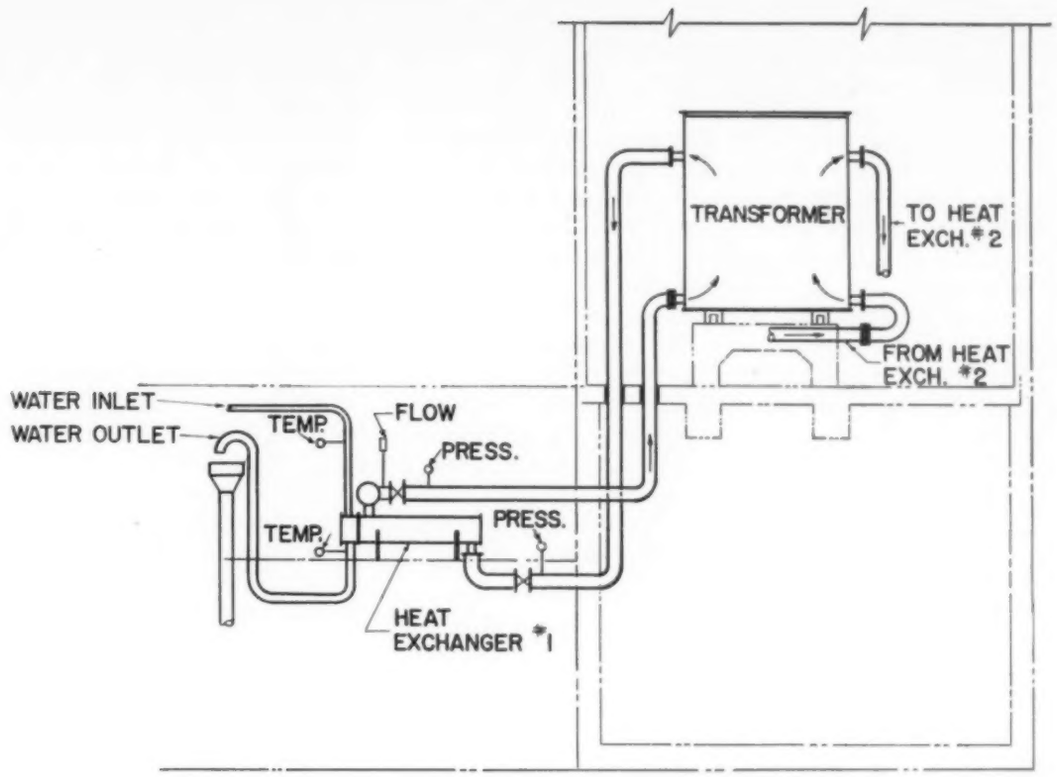


Figure 8 — Schematic shows operation of oil-to-water heat exchangers.

temperature. The neutralization value of transformer oil must also be under frequent well scheduled surveillance. The neutralization number is defined as the weight in milligrams of potassium hydroxide required to neutralize the acid in 1 gr of oil. New oil should show 0.03 maximum. Oil in use should not exceed 0.08. In order to maintain a low neutralization factor, Republic installations make use of thermo-syphon oil conditioning apparatus permanently attached to each transformer bank.

The effectiveness of this apparatus is due to its continuous circulation of the transformer oil through Fuller's earth. When the fixed conditioner is not able to hold the neutralization factor within required limits, an auxiliary mobile filter is brought into use until acidity is back under control.

Moisture control has been given much attention in recent years. Three developments have contributed to elimination of transformer moisture.

1. Forced oil circulation through external heat exchangers in preference to internal copper water-cooling pipes. Forced oil flow is also a good sludge preventive, sludge being a product of oxidation and heat.

2. Sealing of the secondary bus bar apertures in the top of the transformer. This eliminates uncontrolled breathing during the cooling-off period which arc furnace transformers are so frequently subjected to.

3. Application of dehydration breather to each transformer. The name is a perfect description of its function. Sealing of the secondary apertures forces breathing through the dehydrating unit which consists of a rectangular steel container with a glass observation window and a connection pipe located at the top, a breather regulator and another window at the bottom.

The breather regulator consists of two diaphragm type relief valves set within a range of 1 to 8 psi. One valve permits in-breathing, one permits out-breathing, whenever internal transformer pressure exceeds the presetting value, positive or negative.

The container is filled with chloride impregnated silica-gel through which passes incoming air only. As moisture saturation proceeds in the breather, the filtering medium changes from blue to pink. This color change works up from the bottom enabling operators to know conditions by a glance at the glass windows.

Pressure relief valves are considered worth-while contributions in that they are designed to relieve dangerous pressures which may build up and rupture the transformer tank.

Dump valves on tap changer compartment permit the emptying of the 1000-gal oil content in a few minutes. In this case, a ¾-in. valve was replaced by a 3-in. gate valve saving an hour which is used to better advantage during each tap changer inspection.

Improved tap changer leads between transformer terminals and tap changer terminals eliminated bolted connections at both sides of the tap changer barrier. This was accomplished by designing a through-type lead having an oil-type stuffing box at the barrier.

In summary, each Republic arc furnace transformer is now equipped with the following important auxiliary equipment:

1. Three "hottest spot" indicators.
2. Graphic oil and "hottest spot" temperature instrument.
3. Rubber sealed secondaries.
4. Dehydrating breather.
5. Pressure relief valve on main tank and on tap changer compartment.
6. Improved tap changer leads.
7. Dump valve.
8. Thermo syphon oil conditioner.

The practice of silver-plating all heavy connections

in the secondary circuit eliminated heating at joints. This includes transformer terminals, delta connections, cable heads, and tubular bus joints on the furnace.

Careful routing of control and auxiliary motor circuits has eliminated much expensive rewiring after a heat goes through the bottom.

Substituting rotary control for balanced beam has eliminated considerable maintenance work and makes for smoother operating furnaces. No other gains are evident.

Power losses in furnace structurals and roof gland coolers have been lessened. Electrically insulated joints in platforms on top of the furnaces is a case in point. This eliminated a loss of 35 kwhr per hr, per furnace, during the time the furnaces are operating on taps No. 5, 4 and 3.

In conclusion:

Contributions to arc furnace operations summarized in order of importance appear to be as follows:

1. Top charging.
2. Optimum control.
3. Increased secondary voltage.
4. All other improvements.

Approximate average total increase in production due to these improvements equals 70 per cent.

DISCUSSION

PRESENTED BY

D. R. COCHRAN, Application Engineer, Steel Mill Section, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

E. H. BROWNING, Manager, Metal Working Section, Industry Engineering Department, Westinghouse Electric Corp., East Pittsburgh, Pa.

H. H. ANGEL, Electrical Engineer, Construction and Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

L. A. WYND, Superintendent Electrical Department, Republic Steel Corp., Chicago, Ill.

I. N. TULL, Electrical Superintendent, Cleveland District, Republic Steel Corp., Cleveland, Ohio.

C. W. VOKAC, Manager, Hydro-Arc Furnace Dept., Whiting Corp., Harvey, Ill.

D. R. Cochran: Optimum current control which Mr. Wynd mentioned briefly is used in a great number of arc furnace melt shops. Even with its wide usage, I can not help but feel that the term "optimum current" is regarded by many operators as a rather mysterious characteristic of an arc furnace. So, whenever the subject is brought up, I feel compelled to elaborate on it somewhat.

Optimum current is defined as the value of arc current which exists when the kilowatts delivered to the arc is at a maximum. This is shown in Figure 9. But, the optimum current phenomena is not peculiar to an arc furnace. It is present in any circuit, either a-c or d-c. In a d-c circuit, optimum current and maximum power transfer to the load occurs when the resistance of the load is equal to the resistance of the remainder of the circuit including the source. In an a-c circuit, optimum current occurs when the impedance of the load is equal to the impedance of the remainder of the circuit including the source. In an arc furnace, the arc can be represented as an adjustable resistance, and optimum current then occurs when the arc resistance is equal to the impedance of the remainder of the circuit.

Suppose we analyze a simple a-c circuit and learn more about optimum current. An example is an incandescent lamp load on a transformer where more lamps can be added to increase the load. In this case, when the resistance of the load is equal to the impedance of the remainder of the circuit, optimum current will also occur. However, in a circuit such as this, circuit impedance is very low and optimum current will occur at extreme overload conditions. Obviously, the load should be based on the rating of the transformer and not on a so-called value of optimum current.

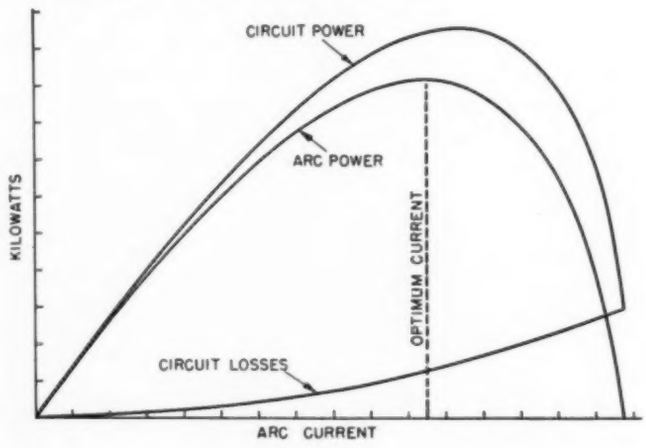
Now, take the case of an arc furnace circuit. It is well known that reactance is required in an arc furnace circuit to give arc stability. It has been found in practice that good arc stability can be obtained with enough reactance to give approximately 85 per cent power factor at full load on the furnace transformer. Since maximum arc power occurs when the resistance of the arc is equal to the impedance of the remainder of the circuit, the high circuit impedance brought about by the use of stabilizing reactance results in the occurence of optimum current at about 130 to 140 per cent of the furnace transformer rating. In this case also, the load should be determined by the furnace transformer rating and not by the value of optimum current.

Herein lies the value of determining optimum current. It enables the furnace user to be sure that the stabilizing reactance being used is at a minimum value required for good arc stability. Minimum reactance is desirable because it gives higher power factor, higher electrical efficiency, and more arc kilowatts for a given value of arc current because more voltage is available at the arc.

During the melt-down period, a furnace transformer is often operated up to about 120 per cent load for faster melting. When the proper amount of reactance is being used, this will be about 10 per cent below optimum current. This is the way most optimum current control systems are set up. Note, that they are not intended to operate a furnace at optimum current.

Optimum current control takes the control of the furnace away from the operator and forces operation

Figure 9 — Curves show arc power, circuit losses, and total circuit power in an arc furnace.



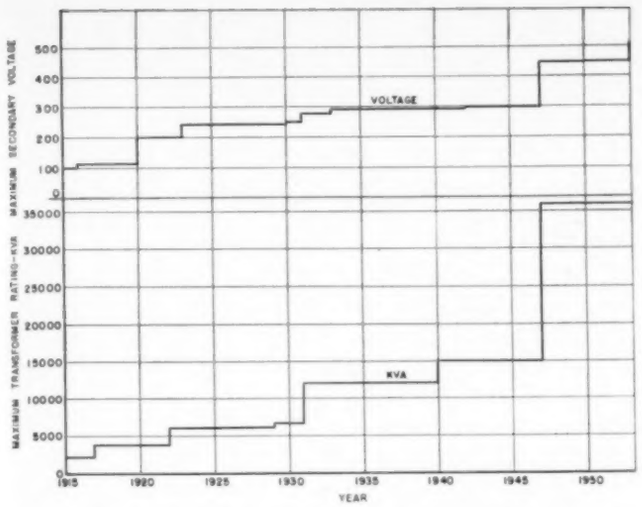


Figure 10 — Chart shows steps made in increasing transformer capacities and maximum secondary voltage over the years.

of the furnace at the best conditions for melting. Increased production and lower kwhr per ton such as was reported by Mr. Wynd should be expected since a big variable is taken away from the furnace operator. Very likely, other arc furnace users could show equally good results by the use of the methods mentioned by Mr. Wynd.

E. H. Browning: The Republic Steel Corp., through the efforts of Mr. Wynd and his associates, has done much to seek out ways and means of improving electric furnace operations. One particularly noteworthy task undertaken was that of amassing considerable statistical data on the effectiveness of optimum current control equipment. This data was published a few years ago, and the author has reviewed the over-all results in this paper. These results show that great benefits in increase in tons per hour and decrease in kwhr per ton of steel are to be had if loading conditions for each particular furnace are determined by investigation and set up automatically for each melting tap voltage by optimum current control equipment.

The author in his concluding remarks, listed "increased secondary voltages" as one of the factors contributing to better arc furnace operation. It is interesting to note how this particular item has progressed over the past years. Figure 10 shows the steps made in using higher furnace transformer secondary tap voltages in the steel industry and the resulting increases in furnace ratings obtained.

Figure 11 shows the general relationship which exists between furnace physical size, kva rating and highest tap voltage provided. As a result of these strides forward, it is of interest to note the effect of the use of larger furnaces, permitted through use of higher tap voltages, on the cost of the electric equipment.

Figure 12 shows the general relation that exists.

Other advancements in the designs of arc furnace electrical equipment are, in addition to those factors discussed, contributing greatly to the increased effectiveness of the electric arc furnace and will continue to do so as its use grows.

H. H. Angel: The use of the special tertiary winding transformers, with the selected combination of impedances, to supply separately the power for the furnaces and mill load is of significance. The application of the "hottest spot" dial type thermal indicators, smoke protective signals, and CO_2 extinguishers for the furnace transformers indicates that better protection than normally used has been made available.

The author indicates that 44,700 hp in 0.8 leading power factor main motors were chosen to improve power factor. This amount of correction certainly should assist in preventing unusual voltage dips. However, I would like to ask Mr. Wynd what correction would have been obtained by the use of synchronous condensers and a lower amount of synchronous motors. One of our plants on the Pacific Coast has an installation of three large electric furnaces operating without a synchronous condenser. Studies made indicate a large synchronous condenser would reduce the dip in voltage and improve power factors to a greater amount than now obtained with synchronous motors. However, the economics of the application would hardly justify its installation.

I wonder if Mr. Wynd is at liberty to give us the kwhr per ton of steel made.

L. A. Wynd: The first question was about the condenser and about all I can comment on that is, I do not

Figure 11 — Increasing shell diameter has of necessity increased power requirements for the furnace.

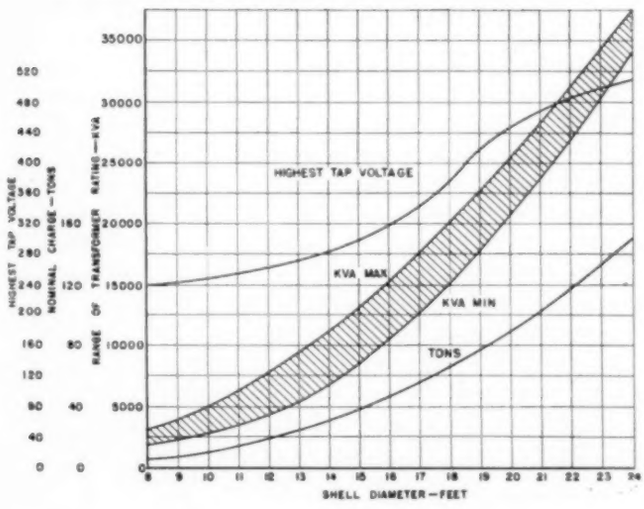
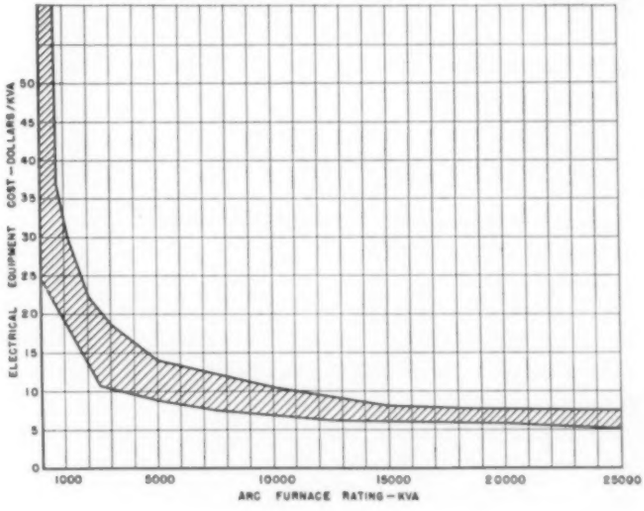


Figure 12 — As furnace size is increased, the electrical equipment cost per kva has gone down appreciably.



think there are any two arc furnace installations the same throughout the country and circumstances, of course, always alter cases.

We have not found it necessary in Chicago for any correction on the voltage dips. Here again, circumstances largely govern. We are only a couple of miles from the Calumet station, one of the large units on the Edison system. Our service comes in at 66,000 volts, three conductor underground cables, no overhead lines, and that in itself helps us with the voltage conditions. We do not know what voltage dips are. Over in the mill side of the load we do get some swings, but not from the arc furnaces. We have been able to pull through without synchronous condensers on the arc furnace section of the load. At Canton we have two very large condensers on the arc furnace section. Arc furnaces sort of grew in that plant. They had a lot of equipment that they could not change and they really needed the condensers.

In our shop we are running about 550 kwhr per ton. Now, other shops, and there again circumstances alter cases, will show better figures than that and we get all kinds of figures when we go around the country looking at furnace installations. Sometimes I wonder if the arc furnace operators are not a little bit like fishermen. They all seem to have better kwhr per ton than we experience.

Please remember that the Chicago installation is an alloy plant, a completely integrated alloy plant. We spend a lot of time refining some heats. Other plants do not go so much for alloys and high carbons. They have runs of low carbon steel. They seem to put their heats out faster and some of them are running under 500 kwhr per ton. We hear figures of 440, 460 and 480 on that type of operation and it is probably right. We cannot do that good with our operations. We do have some heats where we show low kwhr per ton, but, they are usually on low carbon, the product that goes into wire nails and such items and not into forgings and the higher alloys.

I. N. Tull: At our Canton, Ohio plant a number of 12000-kva furnaces were added in the early days of the Second World War, and due to lack of synchronous equipment in this plant, it was necessary to install 40,000 kva of synchronous condensers, in two units of 20,000 kva each. This was done because of considerable savings by virtue of an improvement in lagging power factor, as penalizng our billing, and because we were able to operate more furnaces than was possible otherwise due to load limitations of the power system without such correction.

Our new South Chicago plant was built as a completely integrated plant, and it was possible to include in its electrical design sufficient leading current sources to make it unnecessary to provide separate synchronous condensers to meet the power factor requirement. This was accomplished by putting synchronous motors on some of the reversing mill sets in place of the ordinarily used flywheel-induction motor sets, the need for a number of large auxiliary sets, and means for demand control.

Widely different conditions as regards power supply exist at these two plants. At the Canton plant, the supply is open wire at 24,000 volts, the individual furnace transformers operating directly from that source, while at Chicago the main supply is furnished at 69,000 volts by 3-conductor cables and stepped down to 12,000 volts for the furnaces and 6900 volts for the mills, by means of three winding transformers.

I cite these two cases of electric furnace installations to point out their differences and how the problems they presented were solved. Each case presents its own difficulties and has to be solved accordingly.

C. W. Vokac: Mr. Wynd questions the reliability of a single hot spot temperature indicator and alarm on a three-phase arc-furnace transformer. His point is well taken and should be emphasized. The standard practice for power transformers is not always applicable to arc-furnace transformers.

I noted particularly his statement, "Substituting rotary control for balanced-beam has eliminated considable maintenance work and makes for smoother operating furnaces. *No other gains are evident.*" This checks the statement made last year at this convention in the paper on "A New Way to Control Arc Furnaces"—"... this (rotary) control does little more than what the contactors do—."

Increased secondary voltages were cited as another contribution. But increased secondary voltages without a proportional increase in power (kva) may lead only to increased operating costs. A properly designed arc-furnace and substation will have: (1) an electrode diameter large enough for the shell diameter (being neither oversized nor undersized); (2) a secondary current rating which utilizes the full current carrying capacity of the electrode on all taps, particularly the meltdown and superheating taps; and (3) among other things will have the highest voltage for meltdown consistent with shell diameter, maximum power, and other practical aspects. Most arc furnace costs are fixed or at least in part fixed. Reduction of these costs is dependent wholly or in great part upon increased tonnage output. Such an arc furnace and substation design offers the maximum production and flexibility of operation and at the least cost per ton of output.

Mr. Wynd, referring to the arc furnace switching breakers, states they open and close on an average of 3000 times per month per furnace. Assuming that the furnace is operated 24 hr per day and 30 days per month, the breaker operates on the average every 14 min of the day and night. This is excessive. I wonder how much of that is due to sustained overloading which could be corrected or considerably reduced with higher electrode speeds, faster electrode deceleration and acceleration and faster electrode response? Certainly, the operator does not change taps every 14 min or even 28 min on the average. How much loss of production does this stoppage represent? It is no longer necessary to reverse electrodes with reversing motors. Constantly moving uni-directional electrode motors can develop the electrode accelerations, decelerations, speed, and response necessary to do the job.

L. A. Wynd: The 3000 operations are normal average taken from counters on the breakers and over-current will not account for more than one per cent of it. During the making of alloy steel heats, considerable more tap changing is necessary than in foundry work or in the making of low carbon steels.

Electric Open Hearth Combustion Controls at Algoma

By A. K. BAYLES
Chemical Engineer
and
D. M. STANTON
Fuel Engineer, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

▲ THE expansion program at Algoma included the construction of two 330-ton open hearth furnaces. These furnaces were added to No. 2 shop which now consists of four 165-ton furnaces and the two new 330-ton furnaces.

The 330-ton furnaces have hearth areas of 1,103 sq ft; basic ends, basic front walls and divided uptakes. Combustion air and draft are supplied by the Isley system. The primary checkers have a volume of 11,300 cu ft. The secondary checkers are vertical and have a volume of 2,360 cu ft. Fuels available are fuel oil, with steam atomization, and coke oven gas. Straight oil can be fired or a mixture of coke oven gas and oil. Combustion air limits our firing rate to 135,000,000 Btu per hr.

. . . . for best returns from extensive instrumentation and control systems, considerable training of the first helper is required, although little training is required to familiarize the operators with the elementary operation of the board . . . . despite this, sufficient instruments should be provided so that more efficient operation will be obtained as the operators become more skilled in their use . . . .

Fuel oil is pumped to the shop at 185 psi and approximately 130 F. It is then heated under the control of a recording viscosity regulator to a viscosity of 150 SSU. Steam for atomizing is available at 200 psi but no super-heat. Coke oven gas is generally available at about three pounds pressure. To maintain coke oven gas pressure for the rest of the plant, the four 165-ton furnaces are on gas-oil switching control. Depending on the variations of pressure in the plant main, the flow to the furnaces is varied by a shop control, and the oil automatically adjusts to maintain the total fuel input. When these four furnaces are off, the gas and pressure still decreases, pressure regulators on the two 330-ton furnaces are tripped, driving the gas valves closed, completely shutting off the gas to these furnaces.

An artillery type burner is used, the main six-in. barrel, reduced to four and one-half in. at the outlet, carries the coke oven gas. Twin one in. oil pipes with ½-in. jets are mounted inside the gas burner for oil firing.

The problem of deciding on the controls and instrumentation was made a little more difficult by the intention to use the Isley system with which we had no experience. Also our largest furnace was 150 tons and it was difficult to estimate the firing rates, etc., that would be required. One of the chief functions of instrumentation is to enable the operator to duplicate the conditions that he had found successful. Following directly on this it becomes very important to have a record of the controlled variables. Those features of control with which we had had considerable success on the smaller furnaces, plus a few modifications felt desirable from our experiences, resulted in the following list of nine items for control and instrumentation.

1. Furnace pressure control.
2. Automatic reversal; selector switch for reversal by:
   a. Time.
   b. Checker temperature difference.
   c. Time or temperature difference.
   d. Push button.
   e. Block heat.
3. Provision for manual reversal of furnace.
4. Roof temperature control.
5. Fuel-air ratio control.
6. Oil—steam ratio control.
7. Oil—gas ratio control.
8. Total Btu input control, indication and recording.
9. Recording flowmeters for fuel oil, atomizing steam, coke oven gas and combustion air.

The factors considered in the selection of equipment may be listed as follows:

1. Simplicity of operation for the first helper.
2. Reliability and ease of maintenance along with components familiar to our repairmen. During winter, temperatures at the panels always go below zero and we generally have difficulty with pneumatic controls in exposed locations.

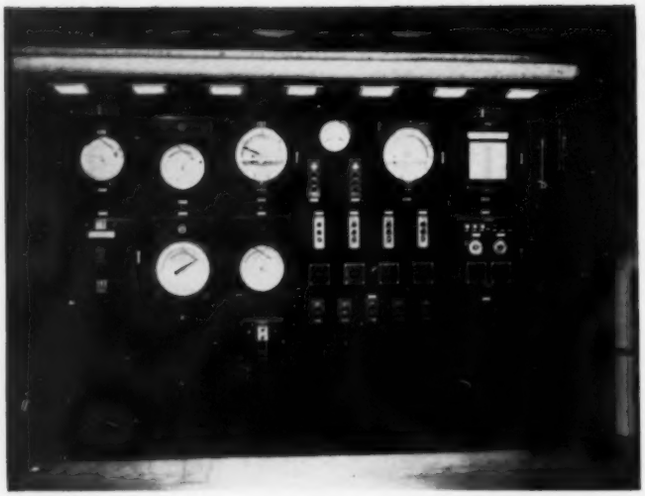


Figure 1 — The control panel is located only 38 ft from the furnace.

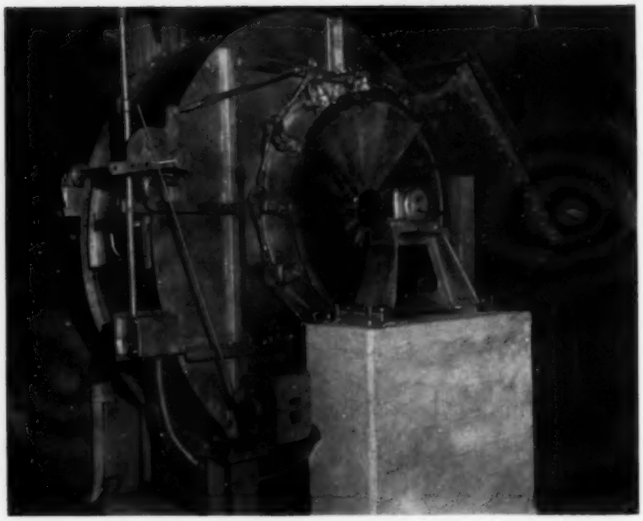


Figure 2 — Control on the ejector fan louvres is fast acting.

3. Maintenance of a certain uniformity of instruments and controls.
4. Limited space available, controls had to be compact.

The decision was made to have an electric control system, except for pneumatic operation of the valves used to reverse the oil, steam and gas. Isley systems are designed with air cylinder operated reversing valves.

One company was assigned the job of providing the complete instrument panel and control equipment to meet our requirements.

CONTROL EQUIPMENT

The control panel (Figure 1) is located 38 ft from the furnace and the charging crane clearance is only 3 ft. Behind the panel runs a standard gage materials track with only 5 ft between the rail and the closed panel. The building columns are spaced at 20-ft centers and a complete span is taken up with the panel and the manual reversing stands.

The panel is actually a cubical enclosure 10 ft long, 7 ft high and 2 ft-6 in. deep. Across the back we have three doors for easy access. We have added an asbestos curtain on a roller to the front of the lighting canopy. One of our panel boards stood up to quite a scorching from a spill out before these were added. They have since proved their worth on several occasions.

The equipment is divided into three general groups, the furnace pressure, the fuel control groups and the furnace reversal unit.

FURNACE PRESSURE CONTROL

On the left is the furnace pressure controller and above it the furnace pressure recorder. The controller has a selector switch for manual or automatic control, open and close push buttons and a control point setter. The signal lights indicate the drive action taking place. Impulse lines run from the furnace to the controller diaphragm. This diaphragm positions a contact on a slidewire which is part of a bridge type control circuit. When the furnace pressure is in balance with its set point, the slidewire contact is in the electrical center and no control action occurs. Any deviation from the control point is immediately detected and the drive unit on the ejector air fan louvres (Figure 2) operates to change the air flow to the ejector, thereby increasing or decreasing draft on the furnace until furnace pressure is at control point and the circuit is in balance. This control features proportional plus reset action and is very fast acting.

The furnace pressure control is interlocked with the furnace reversal unit. The ejector air fan louvres are driven open each reversal which increases draft and speeds up purging.

COMBUSTION AND BTU INPUT CONTROL

Taking up the central portion of the panel are those controls concerned with the fuel rates and flame characteristics. There are five primary functions for this group:

1. To set the firing rate desired.
2. To maintain this firing rate under the control of the roof temperature.
3. To maintain any gas to oil ratio.
4. To maintain a set steam to oil ratio.
5. To totalize the combustion air requirements and maintain a preset air to fuel ratio.

The controlled flows of oil, gas, steam and combustion air are metered and transmitted electrically to their respective receivers on the panel board. The air flow receiver also records and indicates the total Btu input to the furnace. The large Btu indicator is provided for the convenience of the first helper. The chart on this instrument has a 0 to 200 scale, for the air pen it represents 0 to 2,000,000 cfhr and for the Btu pen 0 to 200,000,000 Btu per hr, providing a convenient recording of the air-fuel ratio.

There are four manual-automatic selector switches with push buttons. These provide for manual or automatic operation of the drive units on the oil, gas, steam and air flow valves. Just to the right of the panel board, part of the oil circuit can be seen. Figure 3 shows the oil and steam piping at the manual reversing stands. Identical drive units operate the oil flow and steam

Figure 3 — Oil and steam piping are shown at the manual reversing stands.

flow control valves and the displacement oil meter with its transmitting head is visible.

Figure 4 shows the gas line to the furnace. The orifice flange and flow transmitter are visible. Below the main shut off gate valve is the butterfly flow control valve and drive unit. The pressure regulator that shuts off the gas during periods of low gas pressure can be seen just below the orifice.

Figure 5 shows the combustion air fan and drive unit which operates the louvres to control the air flow. A portion of the inlet venturi and air flow transmitter can be seen.

On the panel (Figure 1) we have four control knobs or ratio setters. The first one on the left is the maximum Btu input setter calibrated 0 to 175,000,000 Btu. The second one is the gas-oil ratio setter calibrated 0 to 100 per cent. This sets the percentage of coke oven gas that will be fired. The third one is the steam-oil ratio setter calibrated 1.5 to 6 lb per imperial gal. The last one is the air-fuel ratio setter. It is calibrated 50 per cent deficiency to 30 per cent excess air. The roof temperature controller, beside the clock, has an external control point setter. This controller operates through a position adjusting type electric control unit to position a motorized slidewire controlling the total Btu input. This unit is mounted below the steam meter in the center of the board. It has a manual automatic selector switch and positioning dial on front of the door to allow manual positioning of the motorized slidewire. The primary element of the roof temperature controller is a radiation pyrometer. This is mounted on the rear wall of the furnace for direct sighting onto the furnace roof.

In this center section, below the clock we have two start, stop switches for the combustion air fan and ejection air fan. Below the ratio setters are the five door switches.

Figure 6 is a diagrammatic layout of these components showing in a simplified way how they are used. Across the top are represented the primary elements for temperature and flow. The conditions desired are set up by the four setters and the control relays adjusts the drive units until the primary elements position their respective slidewire to balance the circuits.

The maximum Btu setter is on the board and is set

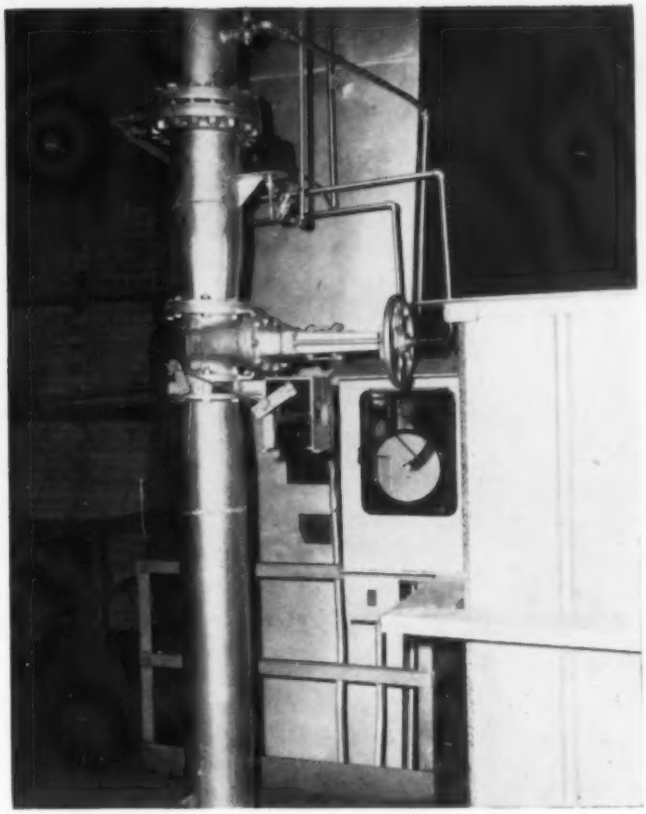
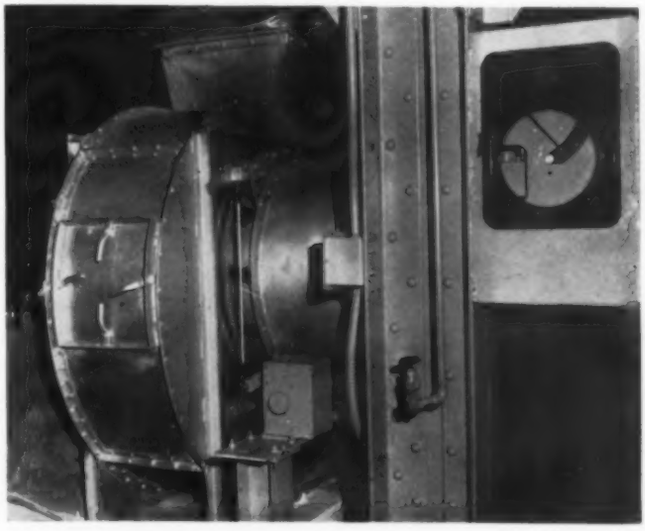


Figure 4 — View shows orifice flange, flow transmitter, and butterfly flow control valve and drive unit.

by the first helper. The roof temperature controller can reduce this setting in order to maintain the roof temperature at the control point but it cannot increase it beyond the maximum set. This setting is actually a voltage which has to be balanced by the relays operating the fuel valves till the fuel flow slidewires create a null balance across the relays. These relays are essentially polarity detecting devices which will actuate a drive unit in an open or close direction according to the polarity of the voltage across the relay. The gas-oil ratio setter sets the percentage of the total fuel that can be fired as coke oven gas. The gas flow slidewire is operated by the gas flowmeter and if the gas is not

Figure 5 — This view shows the combustion air fan and drive units.



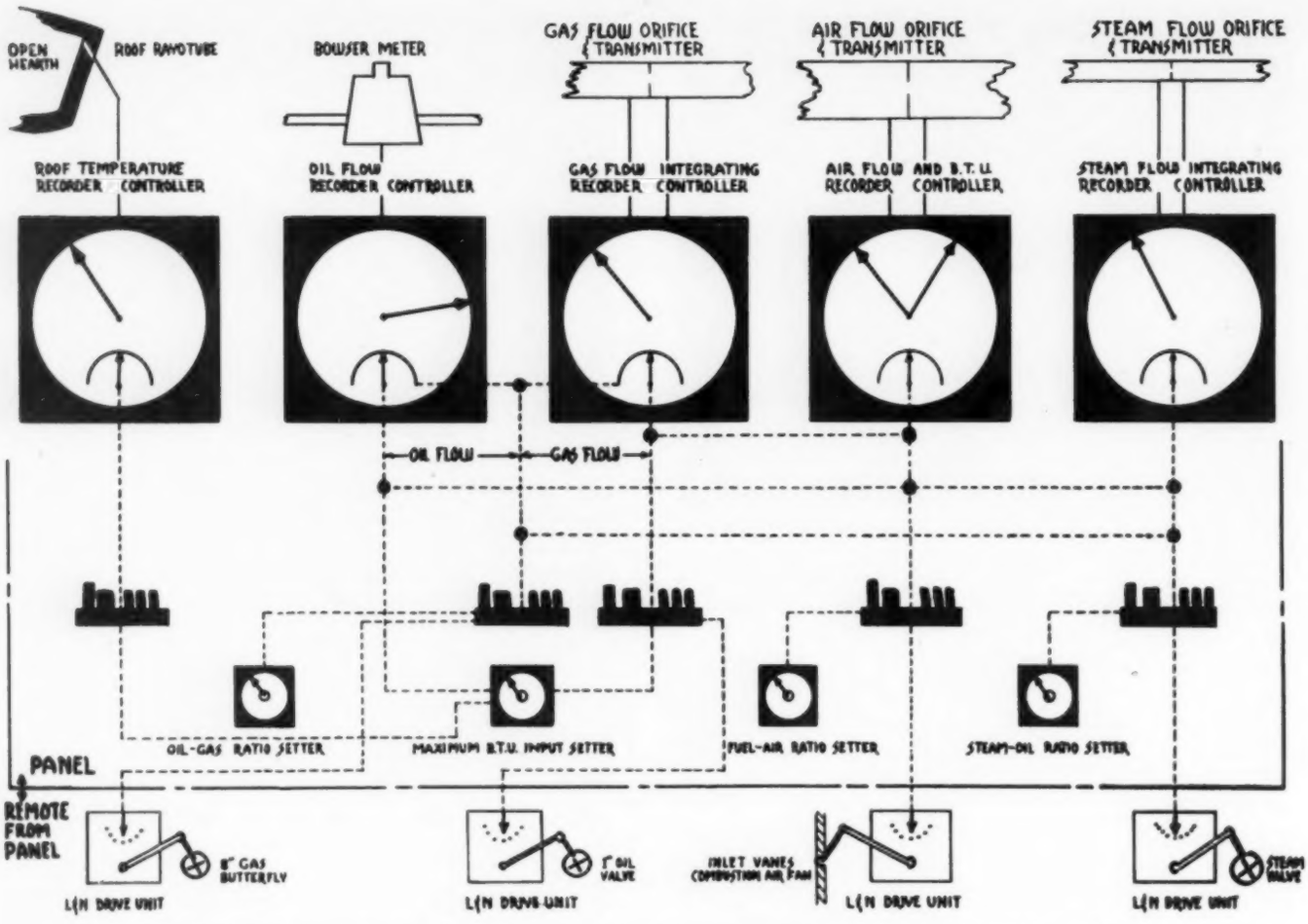


Figure 6 — Schematic diagram shows open hearth combustion and Btu input control scheme.

available to balance its assigned portion of the fuel demand, it is detected by the oil flow relay which will drive open the oil flow valve until the oil flow slidewire brings the circuit to a null balance.

The air-fuel ratio control uses the oil flow slidewire and the gas flow slidewire in series to form a bridge with the air flow slidewire and the relay operates the drive unit on the combustion air fan louvres to position the air flow recorder slidewire and bring the circuit to balance. When either the oil flow or gas flow changes, the relay detects the change and the drive operates to restore the balance. Only a portion of the voltage representing the gas flow is used in this circuit. A rheostat in this circuit allows an adjustment to be made for the different air requirements per Btu of the fuels used. The air-fuel ratio setter adjusts the voltage range of the air-flow slidewire enabling the operator to have an excess or deficiency of air. There is also an adjustment to set the fuel-air ratio required at zero setting of the air-fuel ratio dial.

The steam-oil ratio control picks off the oil flow and the control relay operates the steam valve drive unit until the steam-flow slidewire balances the circuit.

The Btu totalizing circuit for the Btu recorder is separate. A series bridge circuit is used consisting of a slidewire in each of the fuel flow recorders and the measuring slidewire in the Btu recorder.

Control action, initiated by the roof temperature controller causes five drive units to operate through five control units. Sensitivity, proportional band and reset adjustments allow any demand change to be quickly and smoothly handled by these drive units.

FURNACE REVERSAL CONTROL

The reversal control equipment provides either push button or automatic reversal of the furnace firing. We have also laid out our piping providing for manual reversal of oil, steam and gas. Because of the air cylinders operating the throat dampers and air gates of the Isley system, compressed air is required for any furnace reversal. In the event of reversal unit failure, the valves positioning the Isley dampers can be operated manually. We have also used air to operate the fuel valves and steam valves for furnace reversal.

The reversal relay box is panel mounted on the right side. The row of lights across the top indicate the fuel, steam and damper sequences during reversal. The center light shows when the selector switch is on push button reversal, and the light directly below, when the selector is at block heat.

Block heat position was added to our unit. With the Isley system it is a great convenience to be able, with one move, to seal off a heat. Throat dampers closed, fuel off, air off, etc., to seal the furnace.

The two timers allow independent time settings for each end of the furnace. The selector switch on the left has five positions: 1. time, 2. temperature difference, 3. time or temperature difference, 4. push button, 5. block heat. In each of these methods except push button and of course block heat, reversal will take place

when either checker chamber reaches a preset high temperature limit, regardless of time or temperature difference. This is to protect the checkers. The right hand knob is for push button reversal to West or East and is spring returned to center. This can be used at any time to reverse the furnace whether the selector switch is on time, temperature or push button.

Above the reversal box we have the checker temperature difference recorder. This is a strip chart instrument with a single pen recording two temperatures. It records the actual temperature on one end for 10 seconds and swings to the other for fifty seconds, compares the temperature difference between the two with that set by the control pointer on the top scale. This can be used to actuate the reversal. The set point for high temperature reversal is within the instrument and cannot be changed by the operator. The primary elements for this controller are matched radiation pyrometers in the checkers. They are sighted on the center line of the checkers on the underside of the fantail about two feet back of the bull nose. A small bleed of compressed air is fed into the sighting tube to keep the tube clear. No other cooling is necessary and weekly cleaning keeps them in good shape.

Regardless of the method used to initiate automatic reversal the same sequence of action takes place. The main features of the reversal sequence are briefly listed:

1. Alarm horn sounds, this is essential as the ejection air fan and combustion air fans coupled with throat dampers in the stacks are potentially dangerous. If the sequence is not correct the furnace will blow at every door. The fuel cannot come on until the throat dampers are in proper position, but the hot air blowing from the furnace is liable to catch anyone near an opening. Needless to say we keep the sequence correct and normally there is no danger or blowing on reversal.
2. Circuits open to interrupt automatic control of oil, gas, steam and air flows.
3. Reversing valves shut off oil and gas quickly and steam flow shuts off slowly and comes on the other end quickly.
4. Ejector air fan inlet vanes drive open to speed up purging.
5. The four Isley dampers are actuated and their actual individual speeds are controlled by valves on the air cylinders. Limit switches indicating the throat dampers are in proper position stop the alarm horn sounding.
6. The interlock and purge cycle timers begin. Purge cycle ends to restore furnace pressure control and allow fuel reversal valves to open slowly. Interlock timer times out and restores automatic action to combustion controls.

Reversal is accomplished in less than 12 seconds by this equipment. To achieve a fast smooth reversal, the Isley damper sequence must be carefully adjusted and the fuel flow restored gradually.

Figure 7 shows the convenient arrangement of the interlock pressure switches, air solenoid speed control valves on the back of the reversal unit inside the panel board. The pressure gages indicate the rate at which the individual fuel and steam valves open or close.

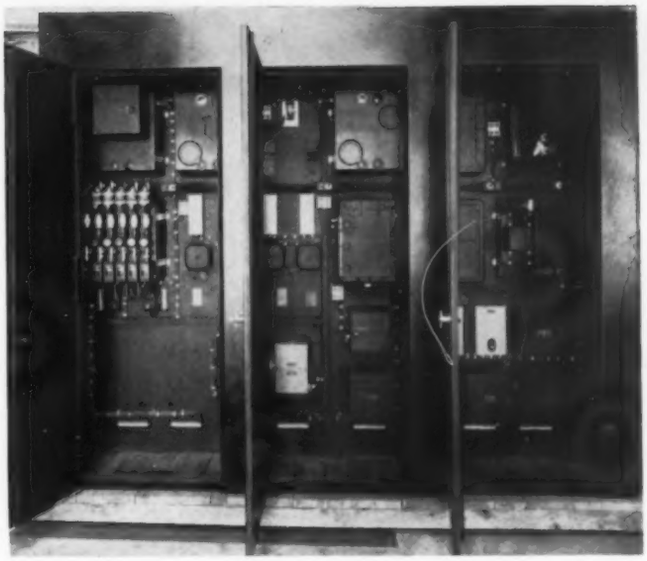


Figure 7 — Interlock pressure switches and air solenoid speed control valves are conveniently arranged.

The reversal equipment is used continually. It is generally used with the selector switch at time and temperature difference. The flexibility is such that we have never had to resort to hand reversal even for maintenance work.

SUMMARY

Parts of this electric control equipment were supplied with voltage regulation. We found it necessary to install a voltage regulator for the rest of the board. This was clearly indicated by a recording voltmeter temporarily installed which showed voltage variations. The voltage going as high as 140 volts. Electron tube replacement has been very low since the regulator was installed.

Very little training was required to familiarize the first helper with the elementary operation of the panel board. With the reversal unit on automatic only, four dials are normally adjusted, the Btu input, the gas-oil ratio, the steam-oil ratio and the fuel-air ratio. The roof temperature control is usually set at the highest temperature the roof can safely stand. It should be emphasized that although the firing rate is automatically reduced as the roof temperature reaches control point, the first helper is responsible if a roof is burned. The pyrometer sighted on the roof is calibrated and cleaned daily, but it is exposed to severe conditions and can be in error. If the first helper believes the reading to be in error he calls for the repairman to check the calibration. Added to the watchfulness of the helper it is a valuable control to assist in maintaining as high a firing rate as possible at all times without endangering the roof.

In deciding how extensively an operation is to be instrumented and controlled, consideration must be given to the personnel as well as the operation. To get the most out of an extensive instrumentation and control system requires considerable training of the first helper. With a view to the future, sufficient instrumentation should be provided so that as the operators become more skilled in its use they will obtain more efficient operation.

SPITZ, DAVIS AND BELL WIN AISE PAPER AWARDS

▲ THE AISE Kelly award for the best paper for 1955 was given to Harry S. Spitz of United States Steel Corp., for his paper, "Water Processing at Fairless Works," which appeared in the January, 1955, issue of the Iron and Steel Engineer. Mr. Spitz, formerly at Fairless Works, is now Division Superintendent, Rolling, Gary Works.

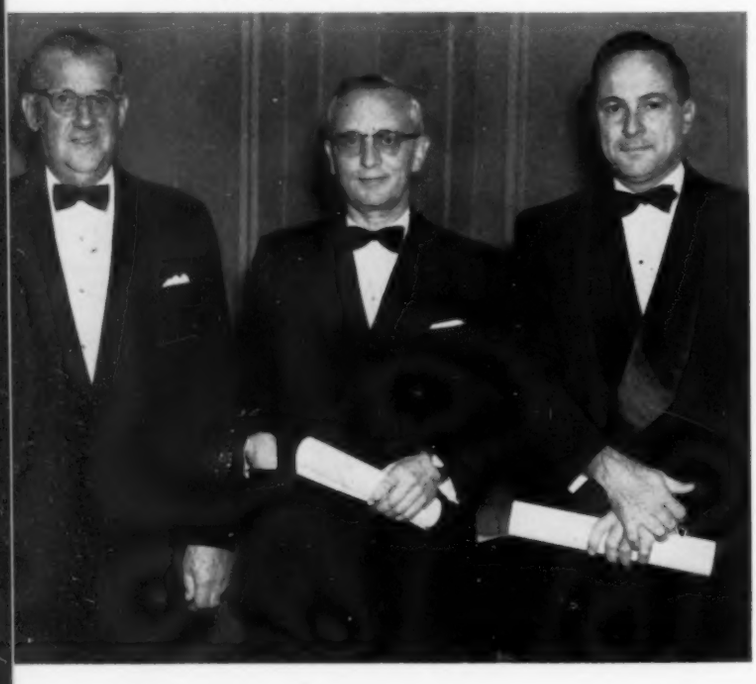
Water is becoming a more and more critical commodity in steel plants. The layout and equipment at Fairless represents the latest thinking in the field and the setup at Fairless should serve as a guide for future installations as the steel industry goes ahead with its expansion program.

Second place was given to D. O. Davis, vice president, engineering, Dominion Foundries and Steel, Ltd. of Hamilton, Ontario, Canada, for his paper "The Oxygen Steelmaking Process," which was published in the October, 1955, Iron and Steel Engineer. This paper on the top blown oxygen converter describes a process which many consider one of the most important developments in steelmaking for many years.

J. A. Bell, chief engineer, Bethlehem Steel Co., Bethlehem, Pa., won third place with his paper on the "Taper vs. Straight Tread Crane Wheels." The form or shape which crane wheels should have is a topic which has been debated throughout the industry for many years. In this paper, which was published in February, 1955, Mr. Bell reported on a number of tests which he had made and which gave actual comparative data, something which has been lacking for full size cranes.

It was difficult for the committee to select the best papers, as there were so many excellent ones to choose from. Several other authors ran the winners a close race. Among the runner-ups were J. P. Katzenmeyer, project engineer, United States Steel Corp., Youngstown, Ohio, with the paper, published in the August, 1955, Iron and Steel Engineer, entitled "New Power, Steam and Blowing Installations at the Ohio Steel Works"; R. S. Bogar, assistant chief engineer, Bethlehem Steel Co., Johnstown, Pa., with his paper, "Hydraulic Systems on Charging Machines and Manipulators," published in August, 1955; and Cecil Schofield, director of laboratories, process and development division, Republic Steel Corp., Cleveland, Ohio, with his paper, "Maintenance Painting in the Steel Industry," published in the September, 1955, issue.

Winners of the AISE paper awards for 1955 are shown at the reception preceding the banquet held at the AISE annual convention Sept. 27. Left to right, J. A. Bell, D. O. Davis, and H. S. Spitz.



The Kelly award carries prizes of $300, $200 and $100 for first, second and third place respectively. The award was established in 1943 to honor John F. Kelly, managing director of the AISE from 1917 to 1934, and to perpetuate the memory of his achievements in the advancement of the Association.

The award is made each year by the board of directors of the AISE upon the recommendation of the editorial and executive committee of the Association.

Rules of the award:

1. The award shall be given annually to the author of the paper, adjudged of greatest value in the advancement of engineering or operating practice in the iron and steel industry.

2. The entries for each judging shall be the papers published in the Iron and Steel Engineer during each calendar year, although some may have been presented at meetings in the previous year.

Voluntary contributions of papers not presented at meetings but published by the AISE are also included in the judging.

3. To be eligible for the award, the author must be directly employed in the iron and steel producing industry. The author need not be a member of the Association of Iron and Steel Engineers.

4. The award shall be made at the annual fall meeting following the close of the calendar year.

5. The award shall be made by the board of directors of the AISE on the recommendation of the executive committee of the AISE.

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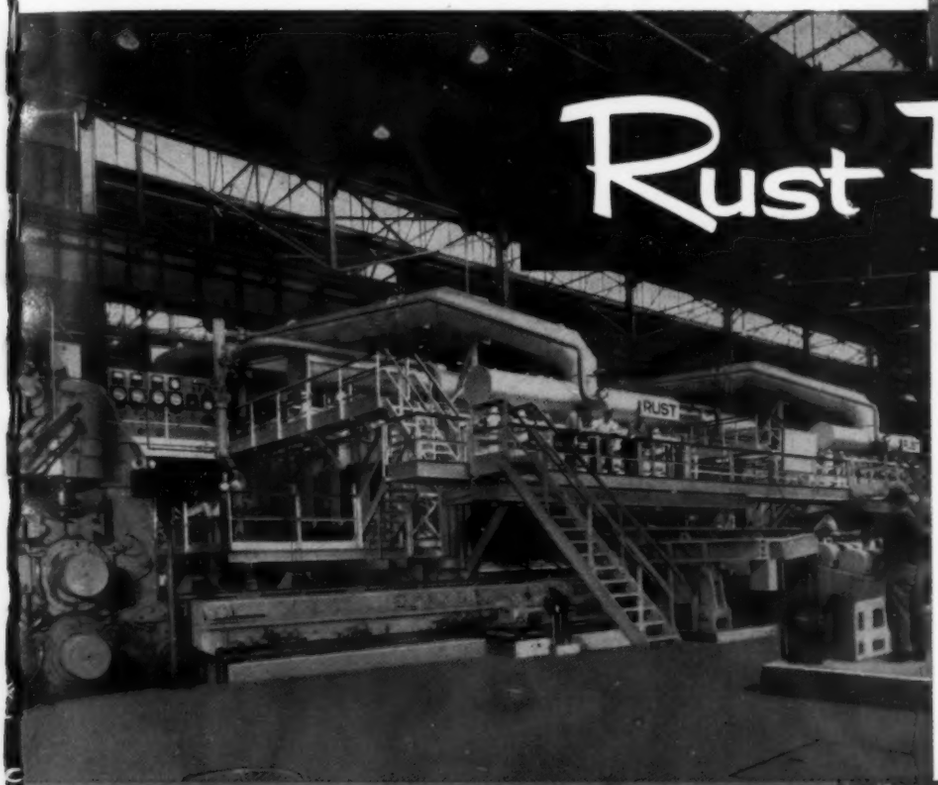

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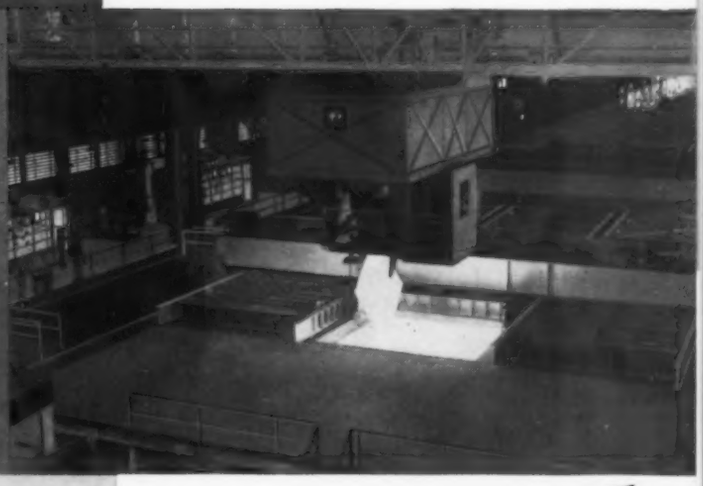

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Russian Log

. . . . one of the interesting features of the annual banquet at the 1956 AISE Annual Convention, September 27, was the following talk . . . .

By LEE WILSON
Chairman
Lee Wilson Engineering Co.
Cleveland, Ohio

▲ GETTING a Russian visa took from February 29th to June 28th, or four months. Getting to Moscow took twenty-five hours by air from New York, via Scandinavian Airlines, Inc.

I frankly had misgivings as we arrived in Moscow at midnight on a rainy July 8th. Russia was an unknown country and it had a sinister reputation under Stalin. I could not help but wonder if it was still a place where people disappeared overnight, if I would be followed constantly by spies, if perhaps I would never return from behind the Ural Mountains. For the first time I really thought about the many visitors to Russia that had ended up in slave labor camps. There was no place to turn for help; we were on our own!

These thoughts kept running through our minds as we hunted for someone who could speak English. Ten minutes of uncertainty and then we met Mr. Kostian Sobolev and Mr. Kolmychkov, our hosts. When Mr. Sobolev smiled and shook hands, I knew we were among friends and when he spoke to us in English, all our troubles evaporated. Never again during our three weeks in Russia did we have fear or misgivings. The Russian people are like Americans—they are friendly, helpful and honest. We liked the Russian people and we found the people of Russia like Americans and America. They still remember that it was America's military help that was the deciding factor in the last war. The Germans gutted and destroyed most of European Russia and killed or starved over 7,000,000 Russians. To the Russian people Eisenhower is not only the victorious general; he is also a friend.

My traveling companion was Dale Miller, a partner in the San Ore Construction Co., of McPherson, Kansas.

Miller and I had fought the war together in the jungles of New Guinea as a couple of Navy seabees. He felt he should go with me to keep me out of trouble and to have a look at Russian civil engineering. He was a wonderful companion and a great help in taking notes and evaluating what we saw. The Russian engineers and he became great friends.

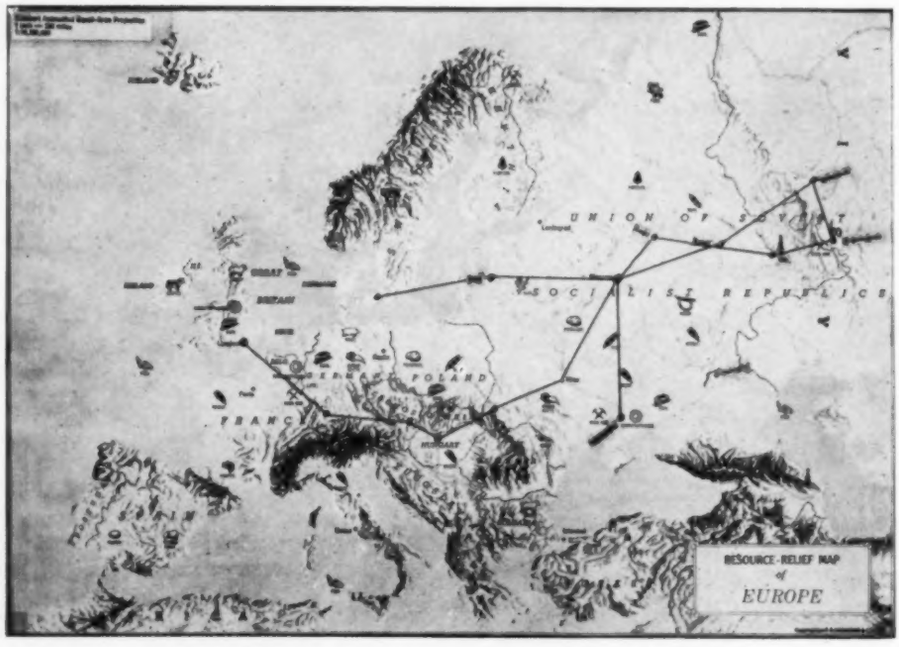
I am greatly indebted to the Russian government for making my trip a pleasant and instructive one. During our visit to the steel centers, we flew as guests in government planes and were housed and entertained at government guest houses. With only two or three exceptions we were encouraged to take pictures and ask as many questions as we desired. We felt that the questions were always answered frankly and as accurately as possible.

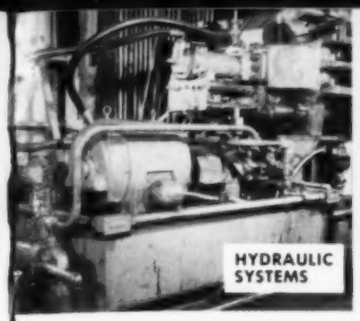
Our itinerary first took us to Moscow, where we had several conferences and met our guide, Engineer Malyshev. Our first trip took us to Karkov and Zaporozhye. Returning to Moscow, we next visited Sverdlovak and Magnitogorsk, which are east of the Ural Mountains and in the Asian part of Russia.

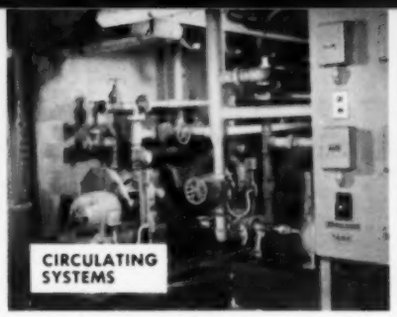
We spent one day in the oil city of Ufa. Finishing our conferences in Moscow, we visited Kiev and left Russia at Lvov on our way to Linz, Austria.

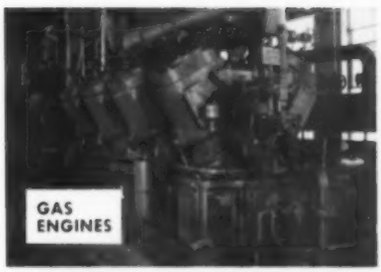
In Moscow we learned that the entire steel industry is managed from Moscow by the Ministry of Iron and Steel. This ministry is divided into five sections — three geographical, one engineering and research and one for special steels. Each plant or area has a local management which has certain local authority having to do with production and labor. Financial

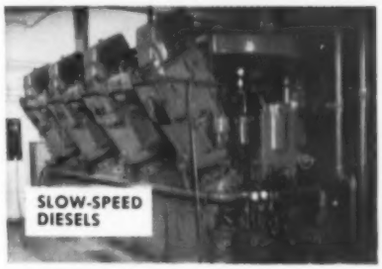
Figure 1 — Total mileage traveled in Russia was over 4800 miles.











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incentives are provided for managers and workers to encourage high production.

All planning, such as production, procurement of supplies, setting of prices and building of new plants and equipment is handled in Moscow at ministry level. Individual plants recommend their needs and wants once a year—in the fall—and then the ministry allocates the production expected, and the necessary supplies to produce the production.

Capital improvements are handled on a five-year plan basis, although additional or supplemental requests can be made each year to help in the fulfilment of the five-year goal. Often these supplemental requests are rejected.

Present planning in the steel industry seems to give preference to flat rolled products. Sheets for automobiles, refrigerators, washing machines and tin plate for canned foods. One engineer in a position to know said 70 per cent of Russian steel capacity since the war had gone into construction of housing and 10 per cent into rebuilding of plants destroyed by the Germans. Now they need sheets for automobiles and strip for pipe for petroleum productions.

At Magnitogorsk we saw a new tin plate cold mill being constructed and plans for a new hot and cold strip mill to roll up to 117 in. wide. The tin mill will produce in 1957 and the 117-in. mill about 1960.

The total ingot production was given as 44,000,000 tons for 1955, an estimated 46,000,000 for 1956 and 66,000,000 for 1960. These figures check closely with those given to the English delegation and those published in several trade publications.

We had a very interesting meeting with Mr. Bardine, director of Iron and Steel Research Institute and vice president of the Academy of Science.

I learned that they have blast furnaces at Magnitogorsk which produce 2000 tons of iron per day, operated on a very high top pressure. The pressure at the bottom of the furnace is two atmospheres. Mr. Bardine states that 85 per cent of all their blast furnaces are now operated as top pressure furnaces.

Mr. Bardine had been in the United States in 1910, and again in 1936, when he had helped purchase a strip mill. He was a very interesting and fine gentleman who spoke English fluently. He is a man well along in years, as the steel industry had a celebration on his seventieth birthday which I understood was two years ago.

Mr. Bardine was very pleased with the production they are getting from their open hearths by the use of oxygen. He stated that they were using oxygen in the burners for firing with mixed coke oven and blast furnace gas and had been able to improve the capacity of the furnace by 25 per cent. He further stated that they felt that the best place to put oxygen in the steel was by lancing it from the roof but so far they have not been able to develop a roof structure that would hold up under this type of application; however, he said they were working on it.

They use a low pressure oxygen system which only compresses to six atmospheres in one stage and is known as a single-stage, low pressure system. It produces an oxygen of about 94 to 95 per cent purity at a cost of about 15 per cent under that of the high pressure methods. He said he was sure that a similar system had been developed and was in use in the States, as he had read about it in our literature.

I asked him if he knew of anything new in the steel industry in Russia that the Americans did not know about and he said he was sure that everything they were doing was familiar practice to Americans. Director Bardine expressed pleasure at my visit to their steel industry and indicated a hope that it was the beginning of a friendly exchange of ideas and engineers.

On July 12th we left Moscow by air for Zaporozhye. At the airport we saw many people from outer Russia and Asia in their peculiar dress. Moscow airport is Russia's busiest field and we saw a great many planes. There are only two types of commercial planes flown by the Russians. A copy of our DC-3 with small engines and a copy of the Scandinavian "Scandia," which looks quite a bit like a Martin-202.

Leaving Moscow, we stopped at Karkov and Dnepropetrovsk on our way to Zaporozhye. During the entire trip we crossed through very pleasant rolling country which was very intensively cultivated. All of the farms which we saw were of the collective type and operated by the collective system, where the farmers all live in a village and work great areas with machines. Each house in the village has its own small garden where they raise sufficient food for their own uses and the bulk of the grain that is raised is taken by the government and sold in the cities.

We were much impressed with the richness of the ground. Of course, most of the area over which we flew is the Ukraine. In the areas that were untillable, such as the rugged valleys and the hill slopes, we saw herds of cattle attended by cattlemen or herders. We could find no evidence of any fences anywhere in the entire trip from Moscow to Zaporozhye. The entire area is owned by the government and controlled as one operation.

Arriving in Zaporozhye, we were met by Engineer Sherbakov who took us on a tour of the city before taking us to the steel mill tavern where we were to live.

The next morning Engineer Sherbakov called for us at nine o'clock and we all went to meet the manager or director, Mr. Yubko, and the chief engineer, Mr. Pudikov. Mr. Shibucko is assistant chief engineer. We spent a very enjoyable morning with Mr. Yubko and Mr. Pudikov in a discussion of the steel industry and commented on a few mutual friends such as Pop Esten and Earle Smith of Republic Steel Co.

Mr. Yubko said that we were welcome to visit any part of his plant that we wished to visit and that we might take pictures if we so desired. Due to poor lighting it was hard to get good inside pictures, although some were taken.

The hot strip mill is one built by United Engineering & Foundry Co. in the thirties. It is a ten-stand 66-in. mill which is fed by four slab furnaces of conventional Rust design. Four new furnaces were to be added this year and construction work was under way. We understood that larger ingots would be used and the mill would be speeded up to take care of the larger production.

The cold reduction department has a United Engineering and Foundry Co. three-stand 66-in. cold mill and one single-stand reversing mill. Annealing is all done in flat sheet form in electric cover type furnaces. Atmosphere equipment consists of two very old style Kemp deox generators which certainly were not pro-

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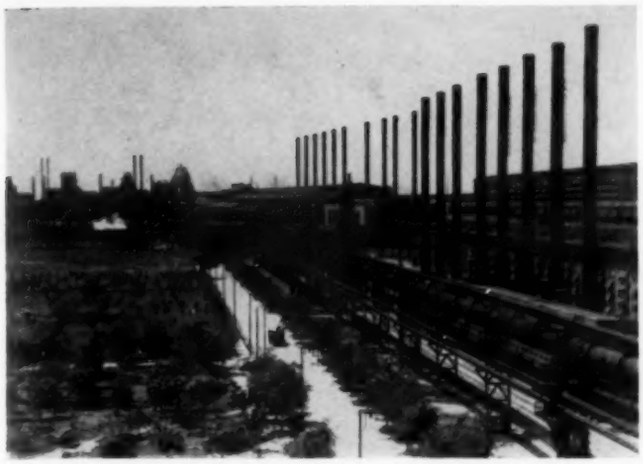

Figure 2 — The open hearth shop at Zaporozhye consists of ten 200-ton basic furnaces.

Figure 3 — The hot mill at Zaporozhye is a 10-stand, 66-in. mill built by an American mill builder in the '30s.

ducing a very clean looking product and two N-X machines using monoethelamine which were designed by Engineer Malyschev.

We did not see any material coming from the N-X machines but all of the other material in the flat rolled department was thoroughly covered with soot. The electric furnaces are 24 in number and are about 60 in. in piling height by about 50 in. in width and appear to be about 150 in. in length.

There are nine furnaces, which they call vacuum furnaces, used for treating silicon steel. These furnaces operate under a vacuum of 25 in. of water. Vacuum pumps are placed in the basement and the furnaces are sealed at the bottom with a rubber seal.

The highest grade of silicon that they make is 3.5 per cent silicon and it is used for transformer stock in a plant located near the mill.

After leaving the sheet plant we went over to visit the thin steel department, as they call it, which we would term the narrow strip mill. In this department they have a number of small mills rolling strip of various analyses down to very thin gages. The quality of the strip seemed to be up to an average grade in the United States.

Annealing is done in four-stack electric convector furnaces of their own design. Coils were about 36-in. diam. 16-in. inside diam and stacked 120-in. high. Production per pedestal was about 0.4 of a ton. The surface of the annealed material was reasonably good. The annealing superintendent in this plant is a woman who has a real technical understanding of annealing.

In their coating department they have five continuous tinning lines which were operating at a good rate of speed making a reasonably good grade of hot dipped tinplate 14 in. wide. All of this material was used in the canning industry and was shipped in coil form with a strip of paper wrapped between each coil. They also have an electrolytic tinning line which processes material the same width at the rate of two tons per hour. It seems to be similar to a ferrostan line in most respects, although its production was low.

The blast furnace shop has five furnaces of 1400 cu m capacity each. The air temperature at the bottom is 850 C and is blown in at 2 atmospheres pressure. The pressure on the top is 0.8 atmospheres pressure. In addition to using a high top pressure, they add 25 grams of steam for each cu m of air and regulate the steam and air very accurately so as to have good control of the moisture content of the air.

I discussed the use of oxygen in blast furnaces and they said that they had used it in the manufacture of ferroalloys but had not had any success with it or had not attempted to use it commercially in the manufacture of pig iron. The furnaces, according to their records, produce 1800 tons per day. They use 800 kilograms of coke per ton and have a repair life of five to six years. They also show that they have eight men per shift per furnace, and that in a normal year's run they produce 2,500,000 tons from the five furnaces.

The furnaces appear to be rather automatic in operation. The loading is all done automatically and is controlled from the control instrument room. A large glass panel shows the location of the skips and the opening and closing of the various valves and the entire cycle could be followed in the control room with ease. It is the writer's opinion that the blast furnace operation is relatively better than the other operations in the plant, which are not as modern or as well done.

One outstanding thing is to see that 30 per cent of the employees in the entire mill, blast furnaces, open hearth, rolling mill, construction gangs are women. They oftentimes dress just like men and it is hard to tell them apart, particularly when they are covered with blast furnace dust or working with a heavy sledge hammer.

No visible dust was coming from any of the furnaces and the blast furnace superintendent pointed out that they were the cleanest blast furnaces in Russia, and as far as I could see, he was correct. There was no evidence of dust or smoke from the furnaces at any time during our visit. They certainly were better than many of our furnaces in the States from that standpoint.

The open hearth shop consists of ten 200-ton basic furnaces. Coke oven and blast furnace gas, mixed, is used for fuel. Oxygen is used in the burners to bring the air up to 25 per cent oxygen content.

Chrome magnesite roofs are used and give an average life of about 420 heats. Tap-to-tap time averages about 7.5 hr. A normal charge will use about 75 per cent hot metal. Production for 1955 was reported as 2,000,000 tons.

Both top and bottom pouring is common practice, the quality and

type of steel being the governing factor.

The workers at Zaporozhye are an industrious, active group of people. Incentive pay is used in all departments. A minimum base rate is paid for a certain quota and a bonus is paid for exceeding quotas, or norms as they term them. Often times a bonus can equal the minimum rate or even more.

The average earnings of a worker at Zaporozhye are about 900 rubles per month. Certain skills, such as rollers or melters can make as much as 4000 rubles per month.

The rate of an annealing superintendent is 1700 rubles per month plus bonus plus certain other extras such as low rent and the use of company automobiles on occasion. The average worker pays about 3 per cent of his earnings for rent in a government apartment or barracks. Superintendents and managers live in individual homes furnished by the company on a rental basis. The rent for these houses are held to about 3 per cent of their earnings.

There are no real estate taxes and income taxes are very moderate compared to ours, as can be seen by the following schedule:

5.5 percent	over 1,800 rubles per year
10 percent	over 6,000 rubles per year
12 percent	over 8,400 rubles per year
13 percent	over 10,000 rubles per year

Thirteen per cent is the maximum tax regardless of income.

In addition there is a compulsory government loan amounting to one month's salary per year, which each worker must lend to the government. Even if the loan is considered a tax, the maximum tax, regardless of income, is only about twenty and a third per cent.

The average work week is 46 hr. Shift work is based on eight hr for the two-day shifts and seven hr for the night shift. Night shift workers receive pay for eight hours. Sunday or rest day work is paid for at double time rates. Clerical workers start at nine am and work until six pm but have Saturday afternoon off.

In general, the steel works at Zaporozhye gave the impression of being well managed. The tempo of activity was high and the morale of the workers appeared good. Pride in high rates of production was very evident.

Housekeeping was bad in comparison to modern U. S. plants, but compared favorably with our plants as they were in the thirties.

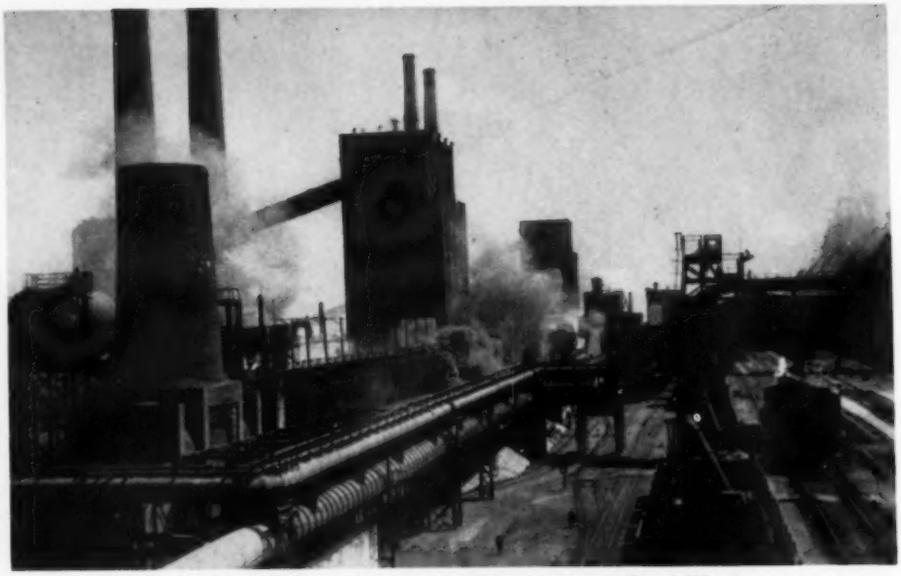

Figure 4 — Coke ovens at the Magnitogorsk Steel Works.

Our host at Zaporozhye, Engineer Sherbakov, was extremely kind and hospitable. He answered or obtained the answers to all of our questions, took us sailing, dined and wined us and filled us full of vodka. He proved, beyond doubt, the great hospitality of the Russian steel men.

Returning from the mill one day, Engineer Malyshev, said that every Russian he knew longed for an automobile of his own. He said that one of the main reasons for the proposed increase in flat rolled products was to take care of the needs for automobiles and canned goods.

It is estimated that Russia produced 110,000 passenger automobiles and 350,000 trucks in 1955. When these are divided among 210,000,000 people, there are not many left after the bureaucrats get theirs. A driver's license in Russia is difficult to get unless you can demonstrate that you are an accomplished chauffeur—which means that you are also a mechanic. We saw only one service station in all of Moscow and garages must be as scarce, as we did not see even one.

After our Zaporozhye visit we returned to Moscow for the week-end. We took time to visit the mausoleum of Lenin and Stalin which was a very interesting experience. As tourists, we were put in at the head of the line which was better than two miles long.

We did not know what to expect but, entering this large marble hall, we found that the interior was very beautiful and very nicely done in some type of dark marble that had iridescent flecks of mica or graphite polished in it. We wended our way down some marble steps and around to the biers and found Lenin to be preserved in a remarkable life-like state in his bed and beside him was Stalin looking just as though he was ready to jump up at any moment.

The preservation of the bodies was a remarkable thing. They both looked extremely life-like and did not have the pallor of death. Stalin was better than Lenin but, of course, Lenin has been dead for many years. Actually their hair was all in place exactly as it should have been. They both looked peaceful and Stalin actually had a little twitch of a smile on his face.

Our trip to Magnitogorsk took eleven hours in a DC-3. Much of the country we crossed in our thousand-mile journey looked like Canadian country-side. We followed the Volga River for miles before coming to the Ural mountains. The Ural mountains were somewhat of a surprise as we had imagined them to be high and rugged, however, we found them to be about like our Allegheny mountains in Pennsylvania.

We were met at the airport by the directors of Magnitogorsk Steel Plant, A. G. Motalin and V. F. Rudakov. We were taken in two big cars to the steel house inn or villa, then we set out for a tour of the city. Magnitogorsk is a city of some 500,000 people. It consists of the steel mill in the Asian part of Russia and the housing part which is in the European section of Russia. This is

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separated by the Ural river. On our tour of the city we went out to the fruit and vegetable farm consisting of some 1250 acres which is operated by the workers at the mill in their spare time.

All of the produce from this farm is consumed by the steel workers. During this trip we also saw quite a number of homes that were owned by the steel mill people. These homes had been purchased from the government by the people and were supposedly theirs forever.

The next morning for breakfast we had hors d'oeuvres, pickled herring, salami, salad, every type of cold meat you could imagine, lettuce and green onions. To start with we had brandy or vodka. After that we had baked ham, fried eggs and a cup of delicious cocoa.

After breakfast we went to the main office where we met F. D. Voronov. He is the managing director of the Magnitogorsk works and the city. In fact, he is what you might call a king in this area, as everything belongs to the government and he is the representative of the government who runs the whole show. Mr. Voronov was a very kindly and keen gentleman. He had a wonderful smile. I would judge that he is about sixty but certainly knows what was going on in the steel business. He, of course, could not speak English and we had to work through an interpreter.

We had a few minutes of conveying messages back and forth between the steel people of the United States and the steel people of Russia, which was all in the very best of humor. Then they asked if I would tell them about the single-stack annealing furnaces and other new developments in the steel industry. It was twelve o'clock before we left his office and I am sure that if it were possible to take an order for a furnace we could have had one that morning.

Leaving Mr. Voronov's office, we went for a trip through the sheet mill, where we saw a three-stand German cold reversing mill reducing three-ton hot rolled bands. The temper mill was a 2-stand German mill. Both of these were one meter wide. All of the auxiliary gear on this equipment was built by CKM-3 which is a machine builder in Kharkov, although we did see some German shears and shearing lines.

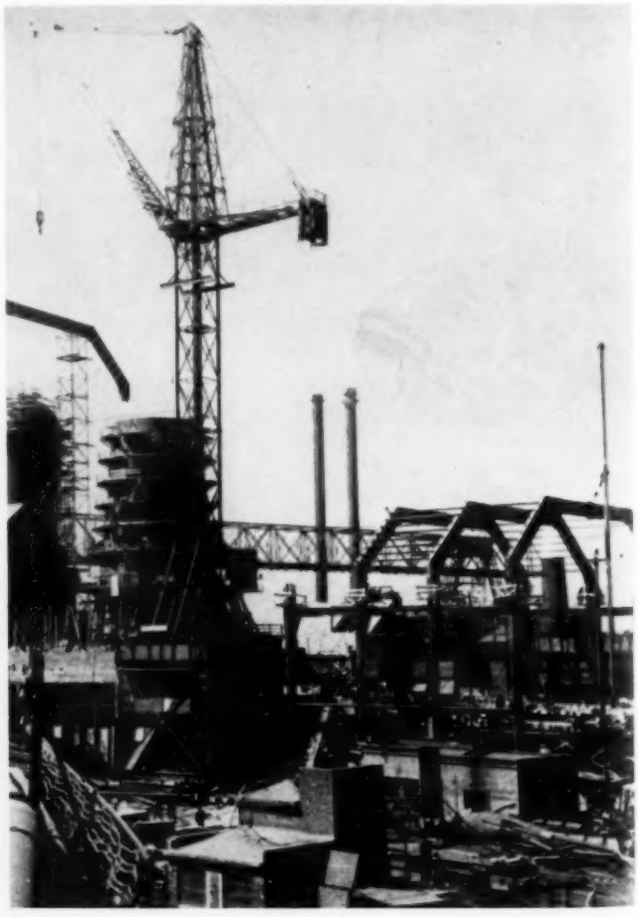
In their annealing they have 16 direct-fired cover type furnaces 48 in. x 220 in. in length. They anneal everything in flats, usually three stacks to a furnace. They also have three electric vacuum furnaces for the treatment of electric steels such as transformer silicons.

The steel was either heavily blued or covered with carbon. The atmosphere machines are of a DX type in which they burn a mixture of coke oven and blast furnace gas. They remove the sulphur with monoethalamine before burning the gas. The capacity of three DX machines was 150 cu m per hr, which did not seem to be sufficient capacity for sixteen such large furnaces, and perhaps a check of the capacity would be some indication of where their trouble lies as far as such bad looking steel is concerned.

We went from the annealing department to the new tinplate department which is under construction. There they are installing a new four-stand tandem mill which had been made at their Ural machinery works at Sverdlovsk. We went over this mill as carefully as we could and from

Figure 5 — There are eight blast furnaces at the Magnitogorsk Steel Works.

Figure 6 — There is a tremendous amount of expansion going on at the Magnitogorsk plant.



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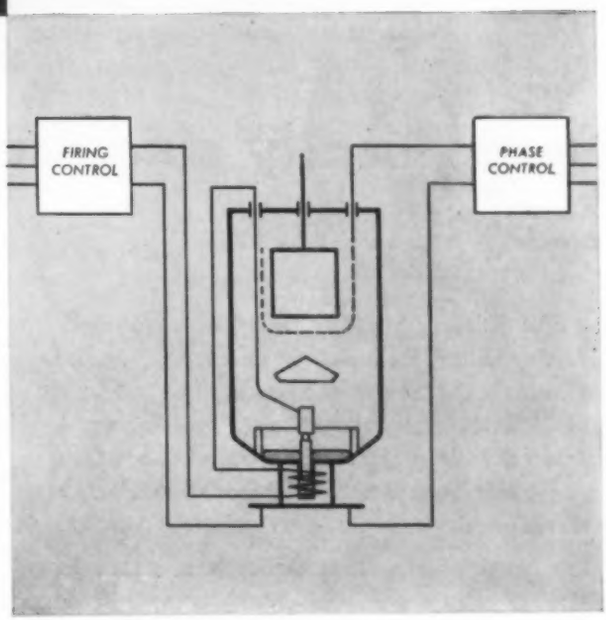

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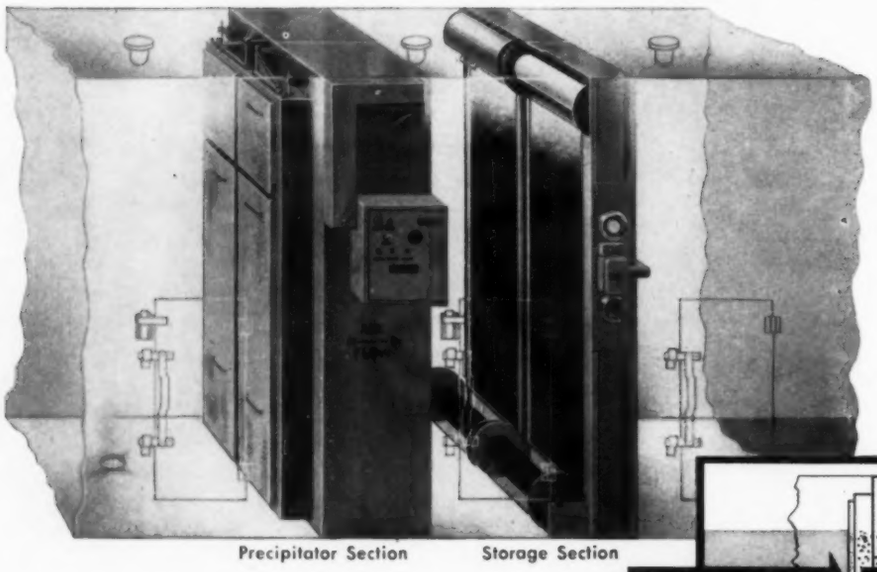

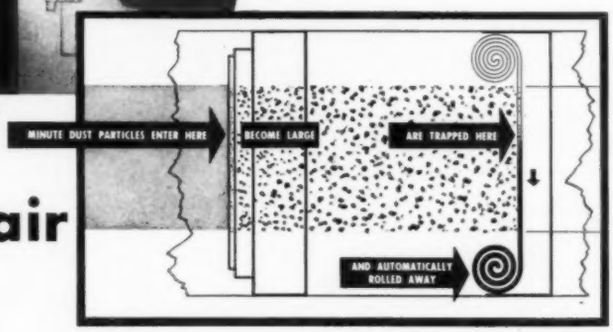

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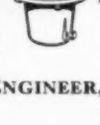
Illinois Heating Specialties

all appearances it seemed to be a very workmanlike job. The control of the mill was entirely hydraulic and the equipment at both ends of the mill seemed to be of the latest design. The mill would operate at 28 meters per sec, or roughly 5000 fpm. Its width is 39 in. or one meter. Motors were 2000 hp built by Electric Mechanic Division of the government at Kharkov. It looked as though the mill would be ready to operate about January, 1957.

The temper mill is a two-stand, four-high mill, 39 in. in width, and runs at 22 meters per second speed which converted would be about 3750 fpm. This mill was also built by their company at Sverdolsk known as the Ural Machine Co. Apparently, Sverdolsk is the center of the machinery industry and many of the things we saw came from that city, which is on the Ural river east of the Ural mountains and north of Magnitogorsk.

We saw two electrolytic lines being assembled that have been made by the CKM-3 machine building section of the government; however, these were not far enough along to tell very much about them. There were several flying shear lines also made by CKM-3 that were installed near the electrolytic cleaners.

The annealing department consists of 14 three-stack direct fired cover type furnaces. Convection heating was to be attempted. The design of the system is pretty primitive and could easily cause sand trouble. There was considerable discussion of continuous annealing, although we could not see any evidence of any continuous equipment or space for it.

The steel melting facilities consist of 28 open hearths in three shops. Thirteen 250-ton furnaces, twelve 200-ton furnaces and three 380-ton units. All of these units are fired with mixed coke and blast furnace gas enriched with oxygen to bring the air to 25 per cent oxygen. Melting practice seems to be the same in all of the Russian plants. Smoke and dust control was excellent at these shops.

There are eight blast furnaces, four of 1360 cu m capacity with 8-m diam, and four of 1180 cu m capacity. The larger ones are supposed to produce 2000 tons of pig iron per day. There are sixteen tuyeres and the air temperature varies between 850 to 900 C. It is blown in at the bottom at a pressure of 2½ atmospheres and they maintain pressure on the top at 0.9 atmospheres. They use an 86 per cent agglomerate which comes from a magnetite hill just above the mill.

They also control moisture content of the blast with steam and said they used a similar amount as was used at Zaporozhye. The iron that they produce has a silicon content of 0.84, manganese 0.18, sulphur 0.41. Slag reports on the same sheet showed CaO 39.35 and MgO 7.1. Mr. Rudakov told me that manganese seldom ever went over 0.2 and normally it was around 0.15, so the day's report of 0.18 fell right in the middle.

This plant is being expanded. Everywhere there is evidence of a tremendous amount of building, not only in the mill itself but in the facilities for housing people. We saw eight or ten tremendously large apartments being built and as many more small apartments.

These people are determined to make a better way of life for themselves and I believe they are making good progress. From casual observation, they have a great deal more labor on most jobs than would be necessary in the United States. Everyone seems to be working, however, at a good rate of speed and there are no people standing around with nothing to do. Supervision seems to be of a high order.

The condition of the plant is not good from the cleanliness standpoint. It is better than Zaporozhye but still a plant that would not stand up to American standards of cleanliness and order. There apparently has not been too much work done on safety, as many of the men were wearing tennis shoes and many of the women were wearing bedroom slippers, even though they were working on construction work. We saw no helmets of any kind nor did we see any shoes of the safety type. There may have been signs about safety but, of course, we could not read them. We went with Mr. Motalin, managing director of the wire mill, to his plant, where we had a meeting with his chief engineer and two superintendents. We talked annealing for an hour and had a very pleasant trip through their wire plant. As we came out of the door of the main office, it looked to us as though most of the workers at the mill were lined up for pay day, but Mr. Motalin said that the employees who were off duty had gathered to see the Americans.

As we went out the door, they all looked at us with great curiosity until I waved, then they all waved and cheered and we went down the street waving to all of the folks and everyone seemed very hospitable and very pleased. As we turned in the mill gate, one elderly lady stuck her head through the fence and excitedly yelled something at us. Before we could reply, she had pulled back into the crowd. Our interpreter said that she had called out that the Russians wanted friendship with the Americans and not war. As far as we have been able to determine on this trip, everyone we came in contact with has felt the same way about it. We have seen no evidence that the Russians wish to have war with the United States, or for that matter, with anyone.

The wire mill was pretty old fashioned, although it was turning out a good quality of high carbon wire. We saw several Vaughn drawing machines as well as a number of Russian built machines. The plant was in the process of being enlarged to double its present capacity. It was interesting to note that Russia makes no fence wire, as there are no fences on Russian farms.

On our last day at Magnitogorsk, we took a quick look at the mountain of magnetite that the city is named after. Ore is mined about two miles from the blast furnaces, taken to a beneficiation plant for sintering, and then either delivered to the furnaces or loaded in cars. Ore is shipped about 900 miles to the Kuznetzk valley, where coal is loaded on the same train for the return trip.

Our hosts, Mr. Rudakov and Mr. Motalin, were delightful people to meet and visit. They did everything in their power to make our stay at Magnitogorsk a memorable one. The last night we were entertained at a typical Russian party in the grandest of style. Wonderful food, fine wine, ample vodka and many fine toasts cemented friendships between the Russian steel men and the American visitors.

Our trip east of the Ural mountains gave us certain general impressions. This is a new industrial country. Much more expansion of industry is evident here than in the Ukraine. Workers are being enticed by

higher wages and better housing to move to this area.

Wages are generally ten per cent higher at Magnitogorsk than at Zaporozhye. Hours of work are the same, and bonuses and incentives follow the same pattern. People are industrious and seem satisfied with their system of government and working conditions. Plant morale seemed high. The steel mill sponsors sports such as football and basketball, and many people take part. Sportsmanship seems to be of a high order.

English is an unknown language in this eastern area. We found no one who could speak our language from the day we left Moscow until we returned, although there are many people in Moscow who speak English. We found several engineers who could print English but could not speak it, and in this manner we carried on most of our technical discussions.

In general we believe that the melting and refining end of the iron and steel industry is well ahead of the rolling and finishing sections. Blast furnace and open hearth practices seem to have had a great deal of attention which has brought good results. The balance of the industry is only now beginning to be brought up-to-date with new mills and furnaces.

Research and development seem to have been concentrated on the basic problems of melting, although considerable work has been done at two separate plants on vertical continuous casting. The progress of both of these developments has been slow although thousands of tons have been cast.

WIRE COIL STRIPPING MACHINE IS MECHANICALLY ACTIVATED

▲ BETHLEHEM Steel Co. has applied for patents on a mechanically-activated wire coil stripping machine, said to be the first of its kind. The new push-button operated machine, designed for the specific task of stripping wire coils from spider peels after annealing and quenching, was developed in cooperation with York-Gillespie Manufacturing Co., and exclusive manufacturing rights have been assigned to that company.

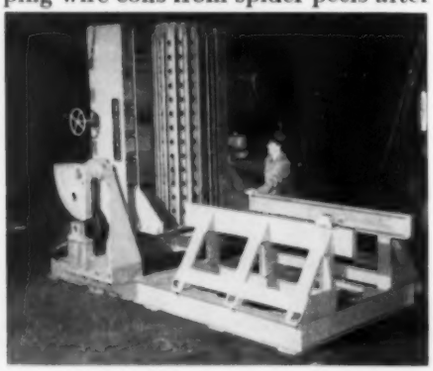

Figure 1 — The spiders with wire coils are deposited on the clamping platform in a vertical position.

It is reported that the first units to be built, now in service at Bethlehem's Sparrows Point Plant, have reduced the time and cost of the stripping operation and have also eliminated the intertwining of coils which often results from other methods of stripping.

Figures 1 and 2 taken during final inspection at the York-Gillespie plant, illustrate the sequence of operations. The operator's control station is not shown in these figures, but in other respects the machine is ready for use. No foundation is required—the machine rests on its own base and can be moved around as needed.

Stripping with this is a four step operation:

1. The spider peel, loaded with coils of wire weighing up to 9000 lb, is delivered by crane and deposited in a vertical position on the clamping platform of the stripping machine (Figure 1).
2. When the operator pushes a button, an air-operated expanding gripper grasps the spider at its inner circumference. The air motor automatically stalls when the grip is in "locked" position.

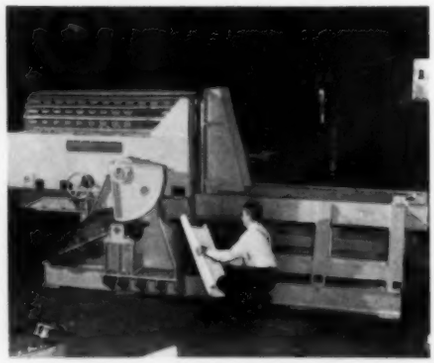

Figure 2 — Platform rotates to vertical position depositing coils in cradle.

3. When the grip is locked, the machine automatically rotates to a horizontal position (Figure 2), depositing the coils in the cradle. Reaching this position, it trips a limit switch and the spider is automatically ejected from the coils to the position shown in Figure 3. The spider plate also remains in the cradle, but is held in position by permanent magnets which are adjustable to satisfy a variety of spider plate diameters.
4. After the coils have been removed from the cradle, by pin hook or fork truck, the operator pushes another button, the empty spider moves forward to the position shown in Figure 2, rethreading the spider plate as it does so, then the machine automatically returns to the vertical position shown in Figure 1, ready for removal.

Adjustment can be made for coils of varying diameters by means of a handwheel on the cradle (Figure 3). Adjustment for spider plate diameter is made automatically at the same time.

Figure 3 — Spider is ejected from the coils leaving coils in the cradle.

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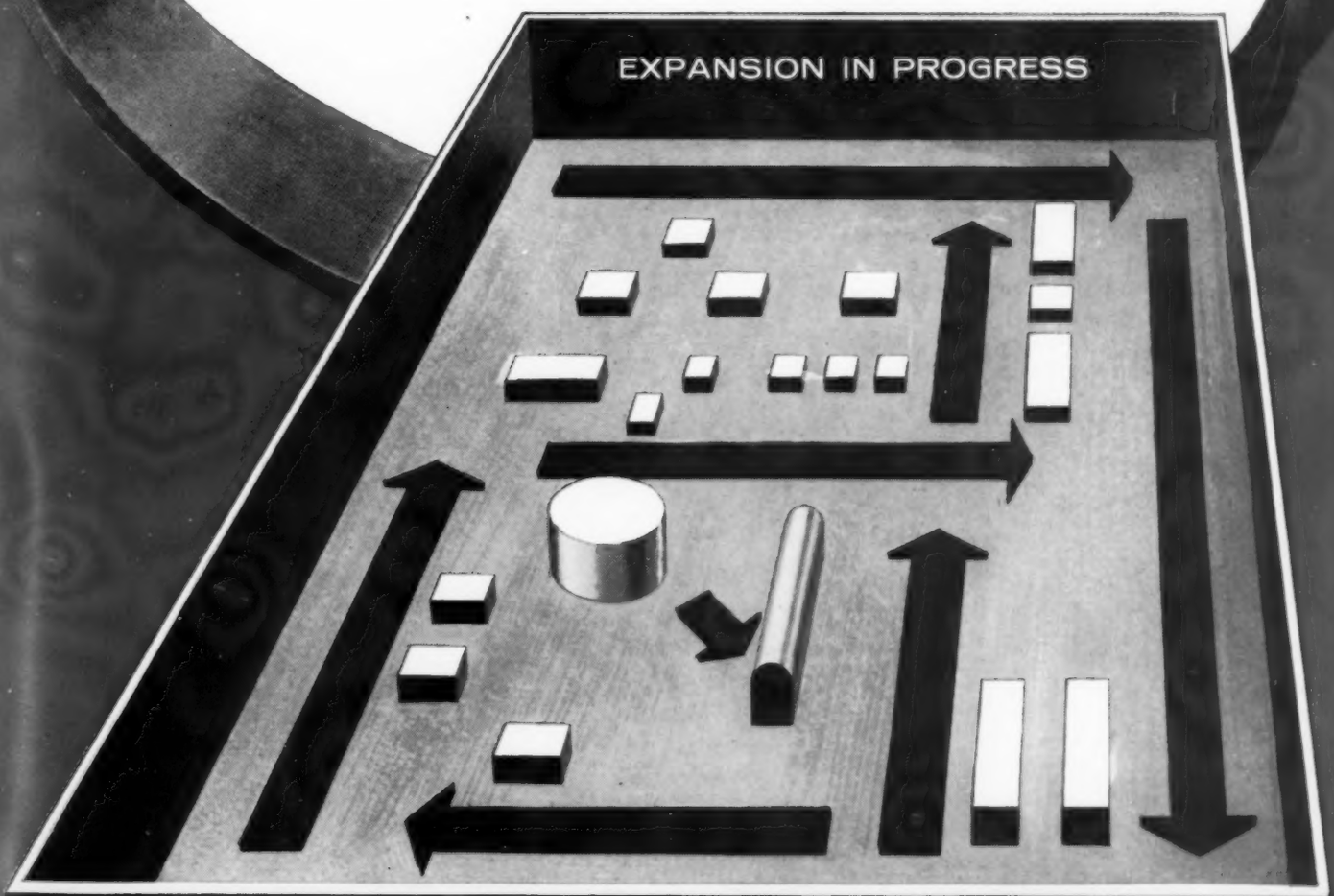

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Card Programmed Control System Applied to Hot Strip Reversing Roughing Mill

By ANDREW W. SMITH
Metal Working Section
Industry Engineering Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.

▲ THE reversing roughing mill at Jones & Laughlin's Aliquippa Works will be capable of completely automatic operation when a card programmed control system developed by Westinghouse Electric Corp. is installed. This new development—the first of its kind so far as known—is identified by the trade name "PRODAC"—representing the general application of programmed digital automatic control to system drives.

Under this system, the operator can press a single button to initiate the complete rolling sequence for a given slab. The speed and roll openings of the vertical edger and the main rolls will be predetermined for a complete schedule by holes punched in a single IBM card.

Of all rolling mills, the reversing rougher ahead of a continuous hot strip mill is one of the most suitable for completely automatic operation. Since mills of this type can be fed with sheared hot slabs of relatively uniform quality, a given strip size can be rolled using a very definite set of reductions. Such variables as slab temperature and type of steel can be taken into account by using two or three schedules to make a particular strip size from a given incoming slab. Typical schedules could call for five passes for hot or soft metal, seven passes for metal of average hardness, and nine passes for the cold or hard metal.

This universal reversing roughing mill feeds a six-stand continuous hot strip mill. To it, slabs will be brought directly from the blooming mill or the reheating furnaces and passed through a vertical scale-breaking edger. The rolls of this edger are each driven by a 500-hp, 360-rpm squirrel-cage motor and are located approximately 30 ft in front of the horizontal mill.

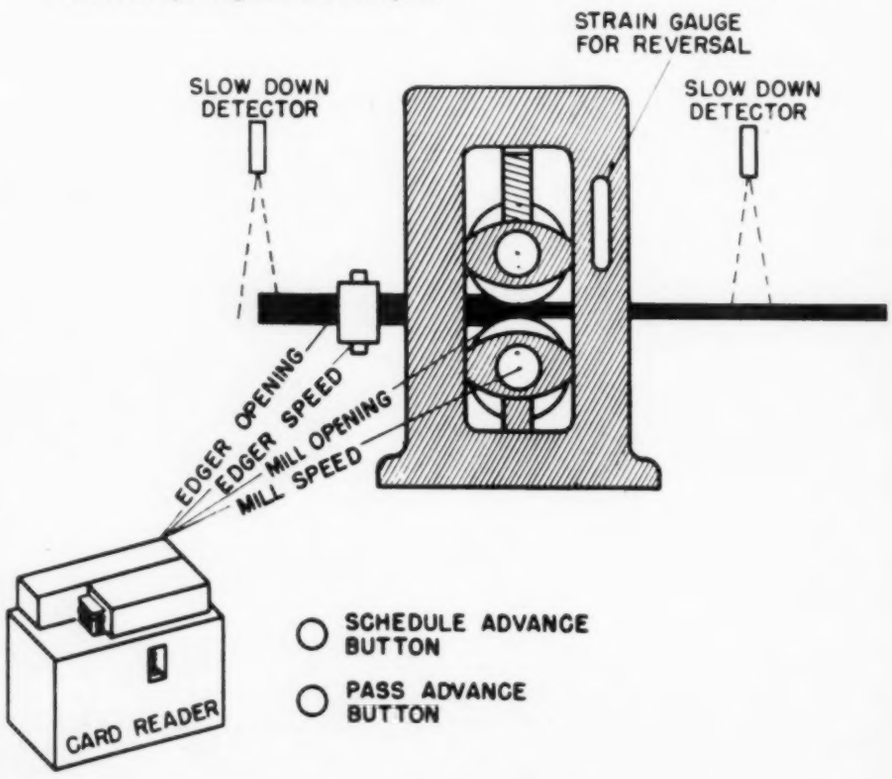
Each of the main horizontal rolls is 42 in. in diam and 44 in. wide and is driven by two 3000-hp, 40/100-rpm motors arranged to form a 6000-hp twin motor. Each of the attached edger rolls is 24 in. in diam and is driven by a 375-hp, 360/450-rpm, 230-volt, frame MC-622 mill motor which is operated up to 460 volts. This attached edger is located 6 ft from the center line of the main rolls.

The horizontal mill screw downs are driven by two 75-hp, 515-rpm mill motors and the attached edger rolls are adjusted with two 50-hp, 550-rpm mill motors.

To initiate a rolling schedule, the operator places a stack of IBM cards in a card reader, in the order in which they are to be used. When the schedule advance button is pressed, the first card passes through the machine in less than a second and all information for that particular schedule is stored in transistor-type memory devices. If several slabs are to be rolled for a given schedule, this information can be used over and over to roll any number of slabs.

Prepared beforehand, IBM cards will be available for practically every slab and strip size and for each grade

Figure 1 — The IBM card inserted in the reader tells the horizontal and vertical rolls the speed and roll opening for each pass. Hot metal detectors initiate the slow-down when the tail end of the strip approaches the mill, and a strain gage in the housing stops the mill and signals for the next roll opening and the next pass.



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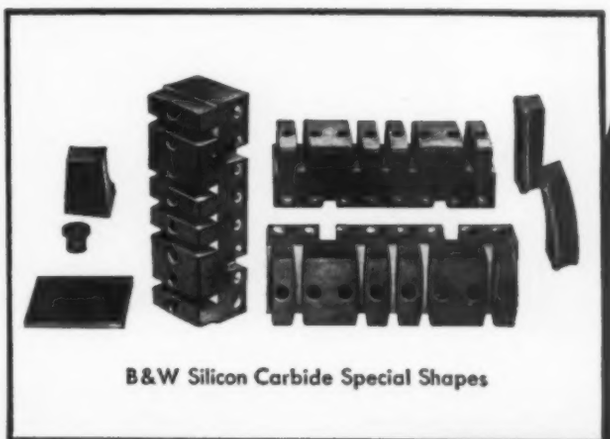
B&W Silicon Carbide Rolls

B&W Silicon Carbide Recuperator Tubes



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of steel. These cards are prepunched to call for the optimum drafts and speeds that give a uniform product at as high a production rate as possible.

A single IBM card includes all information required for a given schedule and controls: (1) mill screw down opening, from 0 to 14 in. in $\frac{1}{32}$-in. increments; (2) edger adjustment opening, from 6 to 44 in. in $\frac{1}{16}$-in. increments; (3) mill speed, at 115, 300, 440, 715, 880, or 1100 fpm; and (4) edger speed, which is matched to mill speed but from 0 to 40 per cent slower to take care of draft in the horizontal mill. Eight five-per cent steps are available. Also included on each card is a notation to indicate the last pass.

To make mill operation completely automatic, a detector that responds to strip radiation is located on each side of the mill. Each of these detectors is approximately 8 ft from the center line of the mill and initiates the slowdown when the tail end of the strip approaches the mill. A strain gage, located on the mill housing, detects the instant the strip leaves the mill for fast repositioning of the rolls and re-entering for the next pass. This strain gage is better able to detect the end of a pass than is an operator since the edging rolls obstruct the operator's view of the horizontal rolls.

After the information for a particular schedule has been read and stored in the transistor elements, the mill is ready for the slab. As the slab approaches the mill, the operator pushes the pass advance button to initiate the following sequence of operations:

1. The horizontal and vertical roll openings are preset.
2. The mill runs in the forward direction at the proper speed.
3. When the tail end of the strip is about 8 ft from the mill, as seen by the slowdown detector, the slowdown is initiated to give a predetermined mill speed of about 300 fpm at the time the tail end leaves the horizontal rolls. At the same time that mill slowdown is initiated, the delivery table control calls for zero speed so that the strip will be delivered onto a dead table.
4. When the steel leaves the horizontal rolls as detected by the strain gage in the mill housing, the mill is automatically brought to rest and the rolls are automatically repositioned for the second pass.
5. When the rolls are properly positioned, the mill runs in the reverse direction at the correct speed.

The cycle of operation in the reverse direction is the same as that used in the forward direction except that when mill slowdown is initiated the delivery table is not brought to rest but continues to run at a slow speed until the tail end of the strip has cleared the vertical rolls as indicated by the slowdown detector on the edger side of the mill.

In operation, the schedules will probably be arranged to make a reduction with the edging rolls in the forward direction only. The card will be punched for even-numbered passes to open the edging rolls approximately four in. from the previous setting to allow the proper clearance between the strip and the edging rolls. The edging roll adjustment can be initiated at the same time that horizontal roll adjustment occurs, when the strip leaves the horizontal rolls. This is true even for the reverse passes since when the table is running at low speed, it will be able to carry the strip clear of the edging rolls before the vertical rolls travel the 3 or 4-in. clearance space.

At the beginning of the last pass, a light in the operator's station at the crop shear will alert the operator so that he can be ready to receive the strip for entry into the finishing mill. After the last pass, the finishing mill approach tables will be stopped unless the operator at the crop shear is ready for the strip and has his table master switch in the forward direction.

The control system includes the equipment necessary to relieve the operator of many operations. The sequence of operation for the rolling cycle can be adjusted to approach the abilities of the best operator. With proper care in preparing the IBM cards and in making the original adjustment of the mill, a consistently high production rate can be maintained, particularly if the production schedule is well organized.

WESTINGHOUSE DEDICATES NEW RESEARCH LABORATORIES

▲ THE new Westinghouse Research Laboratories, located on a 72-acre site in Churchill Borough, about ten miles east of downtown Pittsburgh, occupy a three-story L-shaped structure of red face brick trimmed with stainless steel panels on the office wings. It is 505 ft long and 408 ft wide, and contains 313,000 sq ft more than seven acres—of gross floor space.

Work is organized into 11 departments: chemistry, electromechanics, electronics and nuclear physics, insulation, magnetics and solid state physics, mathematics, mechanics, metallurgy, physics, semiconductor and solid state physics, and technology.

Equipment in the laboratories ranges from such items as a 15-ton bearing test machine to a quartz bar microbalance which is suspended on a wire finer than a human hair and would be taxed to capacity if required to weigh more than a single speck of dust. A cyrostat, a king-sized refrigerator, can plunge temperatures to near absolute zero. Elsewhere, the atmosphere of outer space is approached with delicate apparatus which will create nearly perfect vacuums. Pressures as low as one millionth of a billionth of an atmosphere have been achieved.

More than 700 men and women work at the laboratories. More than 450 are professional scientists, laboratory technicians and assistants. Of

the professional personnel 38 per cent are physicists, 24 per cent are chemists, 13 per cent are electrical engineers, 11 per cent are mechanical engineers, 7 per cent are metallurgists and 4 per cent are mathematicians.

An outstanding technical library contains some 30,000 volumes and subscribes to some 500 periodicals, including technical journals and other publications in a variety of foreign languages.

About 30 per cent of the laboratories' effort is in "blue sky" projects—in work fundamental to the electrical industry, but not directed toward a particular product development. About 55 per cent is co-ordinated with long-range plans of product divisions, most of it being basic research. Eight per cent is taken up in governmental activity. Seven per cent is devoted to product development mostly in highly specialized fields.

Modular planning was the key in designing the interior of the laboratories. Each module measures six feet along the window wall and either 19 or 25 ft in depth. This is the smallest repetitive unit of space that is completely equipped with laboratory and building services. Separated by movable steel partitions, modules can be combined into standard laboratories of 12, 18, 24 or more ft in width. Service facilities supplied to each module include hot and cold water, drains, compressed air, vacuum, natural gas, oxygen, hydrogen, nitrogen, 216-volt, single- and three-phase electricity, 60-cycle a-c; 125-volt, single-phase, 60-cycle a-c; and 110- and 220-volt d-c.

Figure 1 — The new research laboratories are situated on a 72-acre site near Pittsburgh and have almost a third of a million sq ft of floor space.

The building contains an auditorium of 250 capacity and a cafeteria with seating capacity for 240.

Construction is expected to start this fall for an addition to the laboratories that will provide approximately 159,000 sq ft of space. This 50 per cent expansion will be for the materials engineering department now located at East Pittsburgh.

High Speed Quenching Oils Meet Broad Range of Heat Treating Requirements

By S. J. BARBER

Manager of Metalworking Dept., E. F. Houghton & Co., Philadelphia, Pa.

▲ THE heat treating department of practically every steel mill has to handle a great number of different alloys, in many shapes and sizes, and under varying conditions. Obviously, these variables demand some very special properties and characteristics in the quenching oil used if the mill is going to obtain consistent, quality results.

Experience has shown repeatedly that the quenching medium best suited to this broad range of requirements is a treated, all-purpose oil with high quenching speed. Oils in this family have proved highly successful for a wide variety of work, and economical to use, also.

Failure of this important last step in the heat treating process can quickly offset the large investment mills have in equipment, and also nullify the painstaking care and expense put into the heat treating up to that point. Most often, any failure that occurs is likely to stem from use of an ineffective quenching oil.

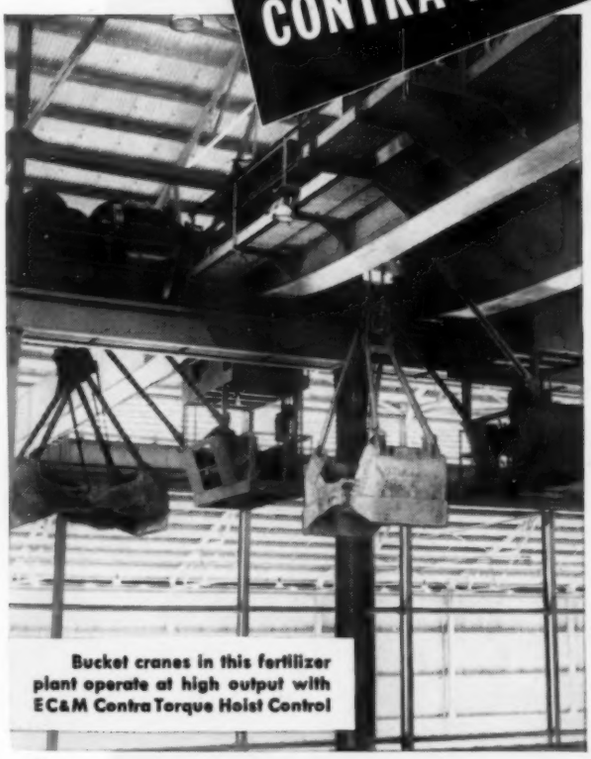
Many quenching oils are satisfactory under ideal conditions when they are new. But most lose a portion of their quenching speed after a period of use because of oxidation, sludging or the selective absorption and carryoff of the quenching speed additives on the surface of the quenched work.

It is often falsely assumed that the most favorable conditions for using a quenching oil, particularly a straight

Bucket crane of the Level-Luffing type operates speedily under EC&M Contra Torque Hoist Control

HERE'S HOW EC&M FREQUENCY RELAY CONTROL improves A-C Bucket Crane performance

CONTRA TORQUE



Bucket cranes in this fertilizer plant operate at high output with EC&M Contra Torque Hoist Control

FAST GETAWAY! Quickly responsive to the frequency of the induced-rotor voltage, **EC&M FREQUENCY RELAYS** match torque requirements to the load. They get the motor up to speed quickly for lowering the bucket and moving the trolley in or out. A lot of time saved between trips!

WIDE SPEED SELECTION! These relays permit starting-down on any master switch point. No waiting until last point is reached. Wider choice of speed gives greater flexibility in clean-up operations and speeds output!

SMOOTH STOPPING! When checking motor-lowering speed, weak torques are provided for light loads or the empty bucket; stronger torques for heavier loads. Trolley motor is stopped and reversed smoothly under frequency relay automatic operation!

SPEED-LIMITING! Safety on all speeds. These relays (one set for hoisting and lowering) automatically shift motor connections to safeguard lowering operation with far greater skill than human hands.

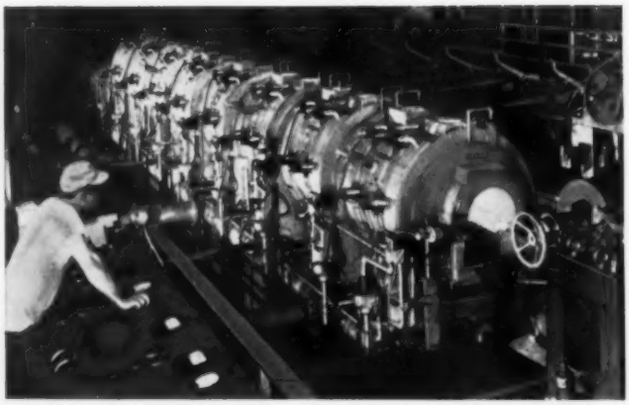
SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

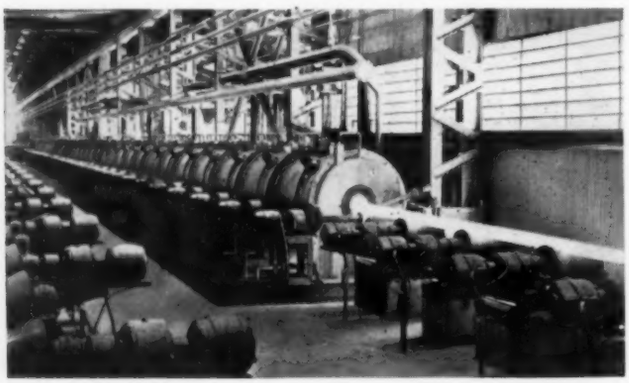
34

Selas Barrel-Furnace Lines Heat Treat Tubes and Bars . . . in Continuous Operations at Mill Speeds

Continuous hardening and tempering seamless tubes at Colorado Fuel and Iron.



Heating for sizing the heaviest wall seamless tubing produced in the U. S., at Phoenix Iron and Steel.



Normalizing welded tubing in 66 sec . . . compared with conventional practice of 21 min . . . helps Lone Star Steel turn out an improved product, faster.

19 steel companies use Selas Gradiation® Heating in specially designed barrel-furnace lines to do a wide variety of heat processing . . . to keep pace with high production demands

Selas barrel-furnace lines throughout the steel industry perform their heating jobs as part of in-line continuous production operations, automatically controlled. The compact, space-saving, gas-fired furnaces deliver uniform heating with speed and precision.

Send for informative articles on Selas tube and bar heating installations. Address Dept. 410.

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers
DEVELOPMENT • DESIGN • CONSTRUCTION

refinery oil, will continue indefinitely. This is not the case because the oil does not remain fresh and undecomposed, and neither do all steels have normal hardenabilities.

SPECIAL REQUIREMENTS

Therefore, it is to the steel mill's best interest that it use a quenching oil that will not change in quenching characteristics over a wide range of conditions including variations in temperature and circulation. The ideal oil should provide the same uniform results for several years at a time. The bath should require no additions of oil other than that needed to make up for dragout losses.

A wide reserve of quenching speed should always be available to compensate for the many variable factors which are present from time to time even in the most efficient heat treating operations.

Variations will always occur in the hardenabilities of different lots of steels. Changes in production may require the hardening of heavier sections. Surface finishes of the heat treated parts may be changed because of manufacturing practices.

With all of these variables, it definitely pays to use a quenching oil with an inherent safety factor even if it is only to eliminate the uncertainties of using quenching oils with limited reserve quenching ability.

Straight mineral oils are not the answer to the steel mill's full neeeds. They are usually average run of the refinery, produced without particular reference to light and heavy ends and sludges. Therefore, they give no guarantee of uniformity of results under varying conditions and prolonged use.

When a hot piece is quenched in a straight mineral oil, some of the ingredients in the oil are "cracked" or distilled off. The oil also oxidizes, resulting in sludge. When these untreated refinery oils are used continually, they tend to thicken and form vapor pockets of low thermal conductivity on the surface of the metal. Cooling is retarded, carry-away losses are increased and the operation becomes more ineffective as use continues.

The range of hardenabilities in certain grades of steel in combination with heavy sections is such that there may be difficulty in consistently producing the required physical properties with a straight 100-second viscosity mineral quenching oil. This is especially so when the alloying ingredients and the carbon contents of the steels are at the low limits of the specification.

HIGH GRADE OIL CHEAPER

When you take a closer look, you can clearly see that there is false economy in the use of a straight mineral quenching oil. Regardless of the low initial cost, the user is actually paying as much or more than he would for a fortified, high speed oil. And this is without obtaining any of the resulting benefits or improvements in quenching uniformity supplied by these new, improved oils.

Actual cases have shown that in most heat treating operations, consumption of the treated oils has been less than one-half that of the untreated mineral oils.

Also consider as a cost factor the excessive sludging, thickening and non-uniform results obtained with a straight mineral quenching oil. These conditions demand periodic replacement of the entire bath. Furthermore, they keep the costs high for cleaning out oil lines, strainers, filters and cooling systems—and for shutting down the equipment to remove such sludge.

ESSENTIAL QUALITIES

The modern high-speed, multipurpose quenching oils are easy to distinguish from the straight mineral quenching oils. In general, they possess the following properties and characteristics:

1. A high and uniform rate of cooling in the initial stage of quenching.
2. A suitable viscosity at the operating temperatures of the quenching oil bath to assure adequate circulation and to reduce the carry-off of oil on quenched parts.
3. Low volatility under the operating conditions of the quenching oil bath. This reduces the loss of oil from volatilization, and also lowers the fire hazard.
4. High thermal stability to resist the formation of sludge, cracking and oxidation of the oil during extended use in quenching operations.
5. A low rate of heat transfer in the final stage of quenching to minimize cracking and distortion of the quenched steels.
6. Uniformity of hardening over a wide range of conditions.
7. Long life. Quantities of a forerunner product in the high speed series have been in use for more than 30 years with only very slight replenishment.
8. Economical. Most of today's high speed quenching oils will quench more pounds of steel per gallon of oil than mineral quenching oils, and with more uniform results.

Figure 1 — Oils for quenching require as much care in their selection as oils for any other purposes.

These special all-purpose oils are recommended for all types of critical and heavy duty oil quenching applications. In practically every quenching operation, they have been found to substantially increase the cooling rate of the quenched work, increase the uniformity of quenched properties beyond expectations, reduce the amount of scale on the quenched piece, minimize carbonization of the oil, and severely reduce sludging and change in oil properties.

Where precision and uniformity of heat treatment are important, these superior oils have played a vital part in extending the service life of highly stressed parts.

The best grades are compounded with oil-soluble synthetic wetting agents which provide rapid wetting-out properties on hot metal surfaces. On quenching, a thin film of oil is rapidly spread over the hot surface of the metal. This film prevents persistence of a gaseous film which would act normally as an insulator against cooling and thus reduce the speed of quenching.

"We had as many as 24 Solenoid coils a month burn up before we installed BUSS FUSTATS" . . .

"Now our burned up coil losses are negligible."

C. R. Babcock, CHIEF ELECTRICIAN
DEWEY PORTLAND CEMENT CO., DAVENPORT, IOWA

Mr. Babcock continues ——

"The burning up of the solenoid coils that activate the plungers that dump our weighing scales was a real problem with us. We lost as many as 4 coils on one 8 hr. shift. The maximum was about 24 coils a month.

"Trouble develops on the days when the gypsum for our cement picks up moisture and sticks to the scales. Then the counterbalance can't reset the scale and, as a result, the plunger moves up and down energizing and de-energizing the thrust coil. The coil has only a few turns of large copper wire and draws a heavy current each time it is energized. It heats up quickly and burns up.

"To give over-load protection to the thrust coil, which is on a 125 volt DC power supply, we installed a 3.2 BUSS Fustat in a series with the coil. (BUSS Fustats are FUSETRON dual-element fuses with a type S base for use on circuits up to 125 volts.)

"Now, when there is trouble the Fustat opens before the coil is damaged. The scale is cleaned and another Fustat installed. We are then back in operation.

"We have three of these scales and at the present time we are replacing only about one coil a month and this is generally due to mechanical and moisture damage.

"We figure BUSS Fustats save us money in two ways — by practically eliminating the cost of replacing solenoid coils — and by greatly reducing our down-time losses."

On circuits of 125 volts or less —

The Proper Size BUSS Fustat can Reduce Danger of Burnout of Solenoids, Coils, Transformers and Motors

A BUSS Fustat is a Fusetron dual-element fuse with a type S base for use on circuits of 125 volts or less. A Fustat gives all the protection of a fuse against short-circuits or dangerous overloads — yet, it permits circuit to be loaded safely to maximum capacity.

Protecting Solenoids, Coils and Transformers —

By installing the proper size Fustat, a solenoid can be protected because the Fustat will not open on the operating surge but will open in time to protect, should the heavy current continue too long for any reason.

A transformer or coil, likewise, can be protected because the long time-lag of the Fustat permits it to hold all normal current surges and harmless overloads — yet it will open to prevent burnout on any dangerous overloads.

Protecting Motors against burnouts —

A BUSS Fustat of motor-running protection size mounted anywhere in the circuit to handle ONLY the motor current will give finest available protection against burnout of the motor.

Nothing else is needed. Underwriters' Laboratories listing gives Fustats same degree of approval for both motor-running and short-circuit protection as the most expensive devices made.

BUSS Fustats stop dangerous practice of tampering or overfuseing

The type S (tampering resisting) base of a Fustat prevents anyone replacing them with an ordinary fuse, a penny or other substitute — or with a size too large to protect.

Fustats fit ordinary Edison base fuse holders through use on an inexpensive adapter that once installed need never be replaced.

Write for bulletin SMPS.

On any circuit up to 600 volts — Use a FUSETRON dual-element Fuse.

Fusetron fuses protect motors, solenoids, coils and transformers against burnout; they offer maximum safety because of their 100,000 amp. interrupting rating; they help increase production by eliminating needless blows and they cut maintenance costs because they are maintenance free.

Write for bulletin FIS . . .

For loads above 600 and up to 5,000 amps. — Use BUSS Hi-Cap Fuses.

When coordinated with Fusetron fuses they will not open ahead of the fuse nearest fault . . .

Write for bulletin HCS.

Play Safe! **Install BUSS Fustats, FUSETRON Fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!**

Bussmann Mfg. Co. (*Division of McGraw Electric Co.*)
University at Jefferson, St. Louis 7, Mo.

956

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

CHICAGO CONCRETE ON THE JOB IN HOURS

500 TONS OF METAL BLASTED FROM SCALE PIT

What do you do when a mixer accidentally pours 500 tons of molten metal into the scale pit of an open hearth shop, putting the mixer completely out of production?

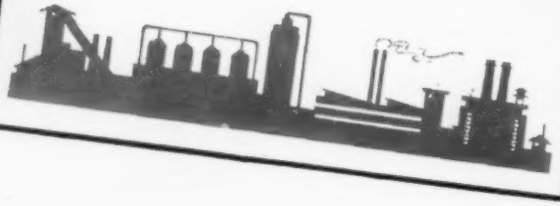
At 3:00 P.M. on a Wednesday in April, 1953 that question was put to CHICAGO CONCRETE. Although the job was over 2,000 miles away, a representative was on the scene appraising the damage in a matter of hours. Simultaneously he ordered out the manpower and equipment necessary to repair the damage while setting to work available manpower in cleaning up. Then . . . coupling the experience bred of 35 years of operation with the judicious use of dynamite, CHICAGO CONCRETE went to work. WITHIN DAYS THE ENTIRE MASS WAS REMOVED AND THE MIXER READY TO RETURN TO ITS JOB.

PRODUCTION TIME SAVED . . . 35 DAYS

By tried-and-proven-safe methods, CHICAGO CONCRETE removed that 500 tons of metal from the scale pit — taking care to safeguard the mixer itself throughout the entire operation. The savings to this mill in "down-time" was literally tens of thousands of dollars. This is another of many emergencies handled by CHICAGO CONCRETE every day, every week . . . handled by experienced men employing the utmost speed. You, too, can depend on CHICAGO CONCRETE in ANY emergency

CHICAGO CONCRETE CONSTRUCTION

Regardless of the size of the job — from a minor masonry, steel or foundation repair, to a complete furnace rebuild, CHICAGO CONCRETE offers you the know-how and facilities to handle any job. CHICAGO CONCRETE CONSTRUCTION COMPANY offers a COMPLETE industrial construction service . . .



CHICAGO CONCRETE BREAKING CO.

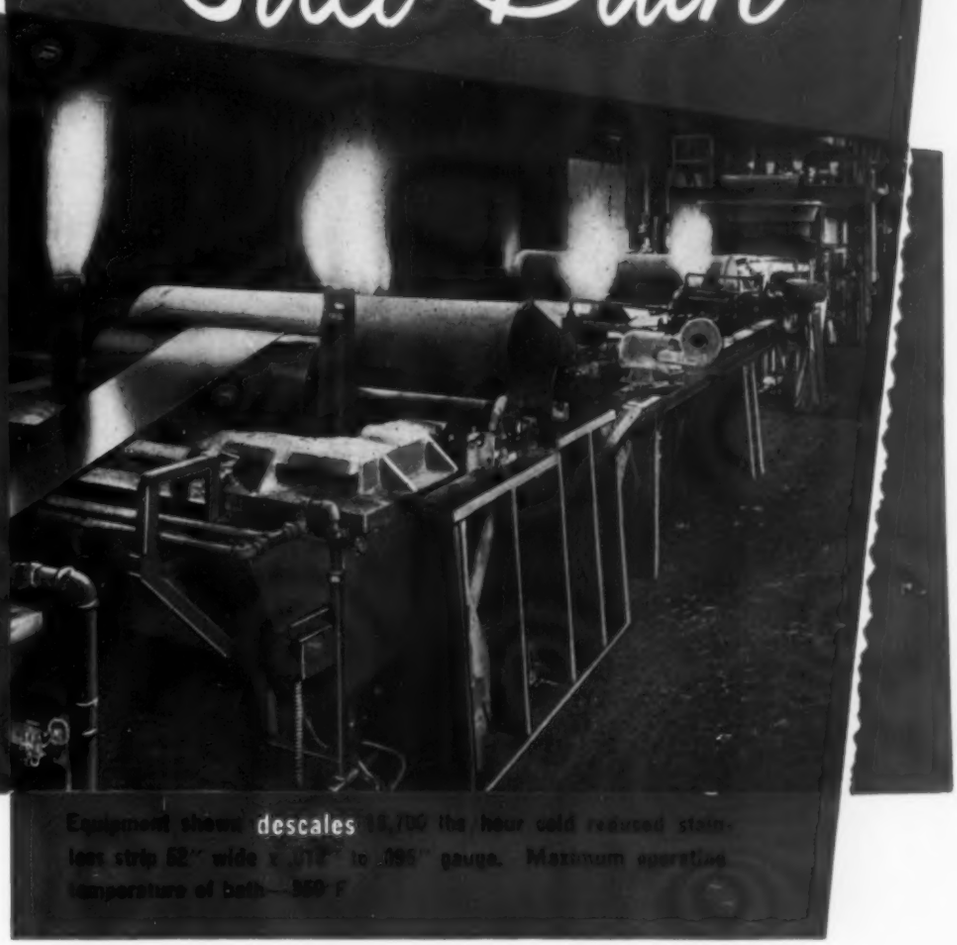
12233 S. AVENUE "O", Chicago 33, Ill., BAyport 1-8400

PITTSBURGH AREA - 213 Corey Ave., Braddock, Pa., Electric 1-1656

SERVING THE PRIMARY METALS AND OIL INDUSTRIES WITH KNOW HOW, EQUIPMENT AND MANPOWER FOR 35 YEARS

DREVER Salt Bath

for CONTINUOUSLY DESCALING STAINLESS STRIP



descales

The above 35'-0" long Drever Continuous Descaling Bath will descale 18,700 lbs/hour when strip enters bath at bath temperature. Entering strip temperature is controlled by regulation of quenching temperature after strip is discharged from a catenary annealing furnace.

Drever descaling baths are heated by gas-fired immersion tubes with proportioning automatic temperature control.

Other baths are supplied for continuous or batch operation for strip, plate, wire, tubing and other ferrous or non-ferrous products.

Write for full information...

DREVER COMPANY

RED LION RD. & PHILMONT AVE. • BETHAYRES, PA.

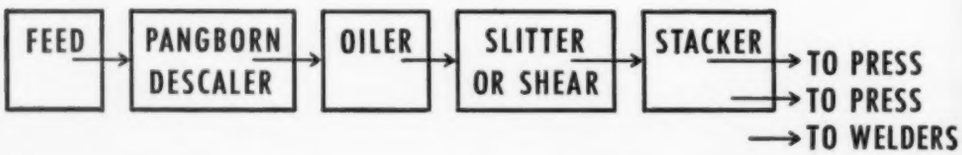
30

STEEL FABRICATORS!

NOW Pangborn offers you

Automation!

For fabricators using flat steel, coils, cut lengths—Pangborn Rotoblast® Descaling Machines offer *straight line* operation. One feed through descaler, oiler, slitter and stacker!



Here's How You Benefit!

- *You cut costs by using hot rolled unpickled steel.*
- *You speed production.*
- *You reduce labor costs.*
- *You eliminate problem of acid fumes and acid disposal.*
- *You use minimum floor space.*

For full details on automation for fabricators, write for Bulletin Number 224 to Pangborn Corporation, 4400 Pangborn Blvd., Hagerstown, Maryland.

Manufacturers of Blast Cleaning and Dust Control Equipment.

VIST OUR BOOTH 1901
NATIONAL METALS SHOW
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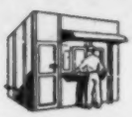
BLAST CLEANS CHEAPER

Rotoblast Blastmaster® & Continuous-Flo Barrel

Rotoblast Tables & Table-Rooms


Special Blast Rooms & Cabinets

Pangborn Dust Control Equipment

VICTOR R. BROWNING
MILL TYPE CRANES
to Specification..

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

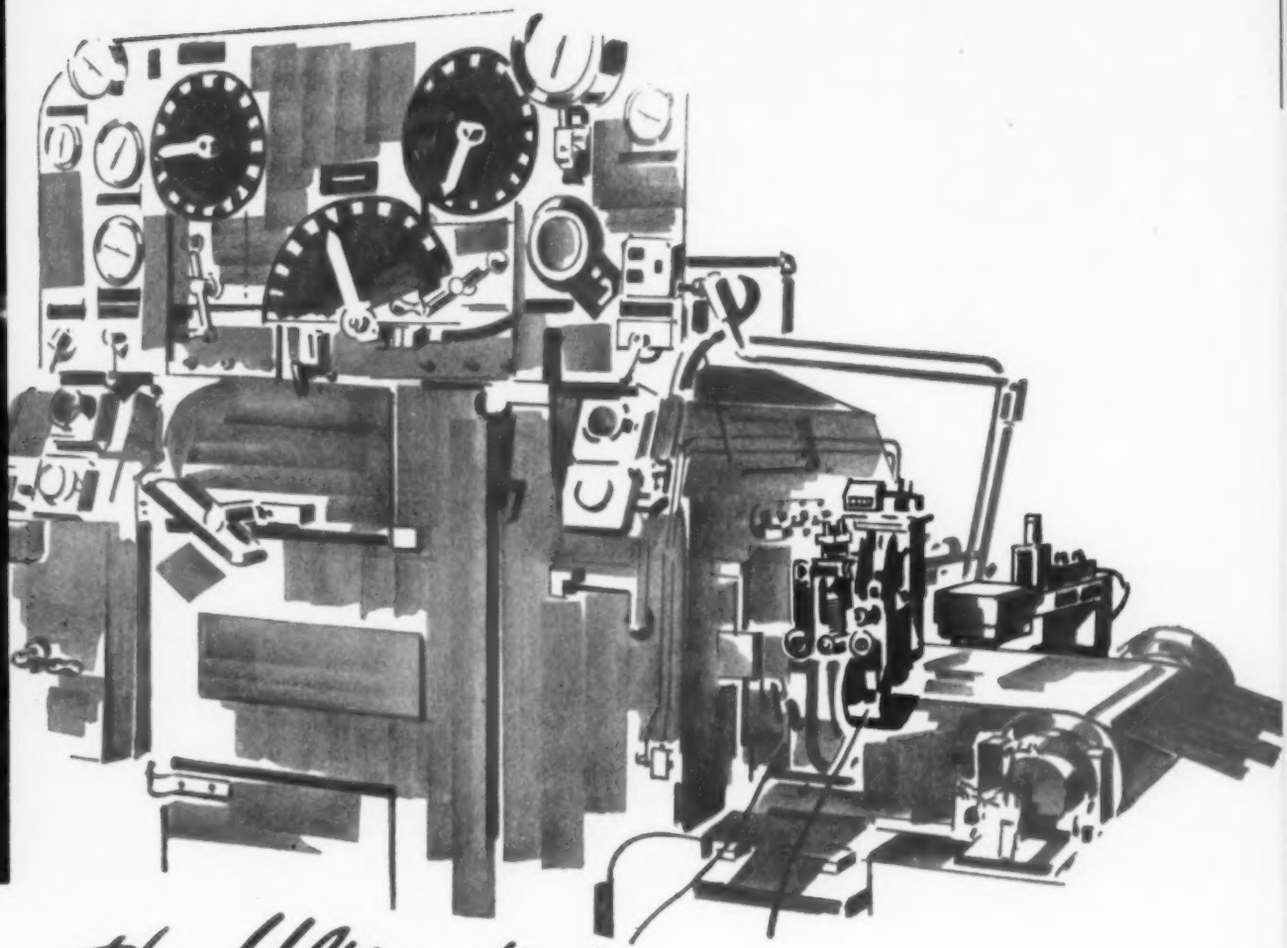
MAINTAIN MATCHLESS QUALITY

with PRATT & WHITNEY

THE X-RAY GAGES and CONTROL UNITS This is a reversing-type mill with duplicate P&W X-Ray Gages on each side. Giving continuous, extremely accurate readings, the gages are non-contacting, cannot mar the most highly finished surfaces. When the gage detects a deviation from nominal strip thickness, it transmits an impulse to the two P&W Control Units which operate to bring the strip back to size automatically. One control corrects the mill screw-down, the other adjusts the tension.

THE RECORDER and INDICATING METERS To provide the permanent production record essential to maintaining rigid, long-term control of strip quality, a P&W Direct-Reading Recorder is incorporated in the installation. This instrument continuously registers *actual strip size* in .0001" increments. As a further check, two indicators (one for each gage) are also provided. These give the mill operator a continuous reading of *strip deviation from nominal* in .00005" increments.

THE TOTALIZER and CARD PRINTER Incorporated in the Control Desk, a P&W Totalizer gives, at a glance, the totals of oversize, undersize, on-size and complete footage in each coil of strip. Providing a permanent record of these totals, a separate Card Printer is located adjacent to the desk. Following the last pass, the operator inserts a card into the Printer, and the information supplied by the Totalizer – plus the date, time, and operator's number – is automatically printed on the card.



. . . the Ultimate in Automation Gaging

FROM ONE SOURCE, ONE RESPONSIBILITY

. . . COMPLETE AUTOMATIC CONTROL SYSTEMS — ENGINEERED TO MEET INDIVIDUAL REQUIREMENTS EXACTLY — FOR MODERN ROLLING MILLS

THE WALLINGFORD STEEL COMPANY of Wallingford, Connecticut, has built an enviable reputation, specializing in stainless steel strip (and tubing made from its own strip) that meets the rigid specifications of exacting customers. Because their requirements permit no compromise with the highest standards of uniform product quality, Wallingford has always invested in the finest, most advanced equipment available. So Pratt & Whitney Automation Gaging was a logical choice. Applied to Wallingford's Sendzimir Mill, this system provides continuous, non-contacting gaging *plus completely automatic* correction of the mill to maintain strip thickness within required tolerances *at all times!*

Phone the P & W Branch Office near you and request a Pratt & Whitney Gage Engineer to call and analyze your requirements . . . or write direct to Pratt & Whitney Company, Incorporated, 28 Charter Oak Boulevard, West Hartford 1, Conn.

PRATT & WHITNEY

FIRST CHOICE FOR ACCURACY

MACHINE TOOLS • GAGES • CUTTING TOOLS

CHEMICAL CLEANING AT THE FORD MOTOR COMPANY, RIVER ROUGE, MICHIGAN

Dowell chemical cleaning gets results for Ford

When you have men and costly equipment in your care you don't take chances. That applies to chemical cleaning, too.

You—like Ford—want the company and the men who do your chemical cleaning to fulfill certain requirements. They must be as safety conscious as you are. This has to be your number one requirement.

Next, you want these men to have extensive experience so that you get the best possible job. And you want them to be backed by research facilities, because you know the best possible job can be done only when the latest developments are employed.

These requirements are basic with Dowell, as thousands of companies throughout the country can testify.

You get them and many more when you have Dowell do your chemical cleaning.

Don't take chances. Have your chemical cleaning done by experts. When you want maximum safety and efficiency backed by research in your chemical cleaning—call Dowell. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. J-29.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

September 1

▲ General Electric announced a 10 per cent increase for repair and reconditioning of most classes of motors up to 499 hp and distribution transformers of 167 kva and below.

September 3

▲ The AISI reports that the operating rate of the steel industry for the week of September 3 is scheduled at 98.7 per cent of capacity. This is equivalent to 2,429,000 tons compared with 2,389,000 tons last week and 2,264,000 tons one year ago. Index of production for the week is 151.2.

▲ Small Business Administration announced that scrap used by steel producers last year totaled more than 81,000,000 tons, having a value in excess of $1,000,000,000.

September 4

▲ Allegheny Ludlum, Pittsburgh, registered $16,377,000 of convertible subordinated debentures due 1981 with the SEC, to be offered to common stockholders on the ratio of $100 of debentures per 23 shares held. Proceeds are to be used to repay outstanding loans, and the remainder for general purposes, including expansion.

▲ Plans to build a $15,000,000 plant in Chicago's Calumet Harbor area with monthly capacity of 17,000 tons of semi-finished billets and slabs have been announced by the Acme Steel Co. The company estimates two years will be required to complete the plant which will be started as soon as a definite site is selected.

▲ Pittsburgh Steamship Division, U. S. S. Corp., signed a 3-year pact with two AFL-CIO maritime unions settling a strike which tied up the company's ore fleet since early August.

September 5

▲ U. S. Steel Corp. filed its third request for tax help by applying for accelerated amortization on the $94,000,000 expansion of its Fairless Works, Morrisville, Pa.

September 6

▲ Alan Wood Steel Co. reported for the first half of 1956, sales of $34,569,000, net profit of $1,287,000 or $1.68 a common share, compared with sales of $26,220,000, and net profit of $892,000 or $1.12 a common share, for the first half of 1955.

▲ The AISI reported that shipments of finished steel products for the first half of 1956 equalled 46,933,786 net tons compared with 41,990,159 tons shipped for the same period in 1955. June shipments totaled 8,077,805 net tons, compared with over 7,700,000 tons in May, 1956 and 7,800,000 tons in June, 1955.

September 7

▲ Government figures show that construction outlays in August were $4,300,000,000, up 2 per cent over July, 1956 and 1 per cent over August, 1955.

September 10

▲ The AISI reports that the operating rate of the steel industry for the week of September 10 is scheduled at 100.1 per cent of capacity. This is equivalent to 2,463,000 tons compared with 2,429,000 tons one week ago and 2,309,000 tons one year ago. Index of production for the week is 153.3. The scheduled per cent of capacity is the highest since April 3, 1956 and marks rapid recovery from the nationwide steel strike and reflects strong demand for nearly all steel products, especially such heavier items as plates and structurals and oil country pipe.

▲ U. S. Steel Corp., Pittsburgh, and Granite City Steel Co., St. Louis, announced increases of slightly more than 1 per cent in the prices of tin plate, to be effective November 1, 1956.

September 11

▲ Steel scrap prices in Chicago rose. No. 1 factory bundles sold at $65, an increase of $3, and No. 1 industrial heavy melting steel brought $62, an increase of $2.

▲ Kaiser Steel Corp. requested permission for fast amortization for tax purposes on coke, pig iron, ingots and wide flange beam facilities at its Fontana plant, and for iron ore facilities at Eagle Mountain, Calif. This request, involving $65,000,000, brings the steel industry's total applications to the total of $846,200,000.

▲ August Thyssen-Huette A.G., Germany, for the fiscal year 1955 report sales of $128,000,000, production of 1,560,000 tons, with earnings of $22,000,000. For 1956, monthly sales have risen to nearly $14,000,000 (a yearly rate of $175,000,000). Current plans for expansion, over the next two years, will increase production 1,000,000 tons by the middle of 1958.

September 12

▲ George Meany, president of AFL-CIO, announced his organization seeks shorter hours for its members without any reduction in pay — to be achieved at the collective bargaining table.

September 13

▲ Detroit Steel Corp. made application for a fast write-off on $16,400,000 expansion of steel ingot producing facilities at Portsmouth, Ohio.

▲ Shippers Advisory Board for the Allegheny region, which includes western Pennsylvania, Maryland, eastern Ohio, and northern West Virginia, predicts that rail freight loadings in this area for the fourth quarter will rise to 918,184 cars, approximately 5 per cent above the year-earlier level.

▲ J. R. D. Tata, chairman of the Tata Iron and Steel Co. Ltd., in an address to stockholders of the company on August 30, said the decrease of about $707,200 in disposable profits was largely due to the lower sales of ferro-manganese and by the large accretions, exceeding $8,320,000, to the Plan Rehabilitation and Development Fund and the Development Reserve under government's new retention price scheme. He discussed the company's new expansion program which will increase the company's ingot steel production from the present target of 1,300,000 tons annually to 2,000,000 tons annually, within a period of three years at a cost of about $125,000,000, and advised contracts have been placed with two divisions of the Henry J. Kaiser Co.

▲ Shareholders of Acme Steel Co. voted approval on new issue of 400,000 common shares, proceeds to be used for the purchase of the property and assets of Newport Steel Corp., Newport, Ky.

September 14

▲ Reserve Mining Co., jointly owned by Armco and Republic Steel Corp., yesterday dedicated the E. W. Davis Works. The $190,000,000 project has been in operation nearly a year and has produced nearly

2,000,000 tons of pellets. Ultimately the plant is designed to produce 3,750,000 tons of iron ore pellets annually.

▲ Shipments of iron ore, coal and grain down the Great Lakes decreased more than 11,000,000 tons up to September 1, 1956 from the same period in 1955. The Lake Carriers Association ascribed the drop to sharp curtailment in the iron ore movement during July and August due to the steel and maritime strikes.

▲ Rules for licensing exports of iron, steel scrap abroad were eased by Commerce Department. Bills of lading will not be required and licenses will be granted on less than a cargo-for-cargo basis. Certification is required that the scrap covered by export applications is available for export.

September 17

▲ Home building contract awards in the 37 states east of the Rockies in August, according to the F. W. Dodge Corp., amounted to $2,068,754,000, an increase of 9 per cent above August, 1955.

▲ Three more steel firms, Inland, Crucible and Lukens, requested the Government for fast tax write-offs on additions to their facilities costing approximately $203,000,000. This pushed the total of these applications from the steel industry in recent weeks above $1,000,000,000.

▲ Tin prices advanced sharply in New York and London last week as a result of the seizure of the Suez Canal; spot copper also firmed up in London, affected by unsettled labor conditions in Northern Rhodesia.

▲ The AISI reports that the operating rate of the steel industry for the week of September 17 is scheduled at 99.6 per cent of capacity. This is equivalent to 2,452,000 tons compared with 2,477,000 tons one week ago and 2,320,000 tons one year ago. Index of production for the week is 152.6.

▲ The Agriculture Department reported that farm income is now running at an annual rate of $12,000,000,000 or higher, achieving its best level in 2½ years.

September 18

▲ United Steelworkers opened a convention in Los Angeles celebrating its 20th anniversary and newly-won three-year contract. David J. McDonald outlined a program for the future that included fewer hours of work, improved benefits, and "sharing the wealth of American industry."

September 19

▲ Iron ore shipments down the Great Lakes last week rose to 3,252,527 tons, an increase of 565,000 tons over the previous week and 309,709 tons over one year ago.

September 20

▲ Lone Star Steel Co. increased prices about $10 per ton following a settlement of a 13-day strike in its East Texas plant.

▲ Deliveries of new domestic freight cars in August totaled 5364 cars compared with 5344 in July, 1956 and 3480 in August, 1955. Orders in August totaled 2575 compared with 2642 in July. Backlog of cars on order as of September 1, stood at 122,870 cars.

September 21

▲ Loans to business by leading New York banks amounted to, at the close of business Wednesday, September 19, to $10,762,000,000, an increase of $1,500,000,000 since January 1, 1956 and $2,200,000,000 above the year-earlier level.

▲ The Industrial Heating Equipment Assn. reported that orders for industrial furnaces during August amounted to $6,721,789 compared with $6,273,053 last year.

September 24

▲ The AISI reports that the operating rate of the steel industry for the week of September 24 is scheduled at 100.2 per cent of capacity. This is equivalent to 2,466,000 tons compared with 2,477,000 tons one week ago and 2,341,000 tons one year ago. Index of production for the week is 153.5.

▲ Orders for machine tools in August totaled $87,400,000, a 41 per cent gain over July, 1956, and brought the total for the first eight months to nearly $658,000,000 33 per cent above the same period in 1955.

▲ Prices of steel scrap in the Chicago area were off $1 a ton on the first two grades.

▲ Living costs in August dropped 0.2 per cent; with the government index at 116.8 per cent of the 1947-49 average. This is 2 per cent higher than August, 1955.

▲ National Carbon Co., a division of Union Carbide and Carbon Corp., announced an 8 per cent increase in the price of carbon and graphite electrodes and anodes, effective September 24.

▲ The Colorado Fuel & Iron Corp., for the fiscal year ended June 30, 1956, reported sales of $341,630,224 compared with sales of $257,543,050 for the previous year; net income amounted to $16,662,653 or $4.74 per share in 1956 compared with $10,887,163 or $3.79 per share in 1955.

▲ Shipments of iron and steel castings during June, 1956 amounted to 1,392,000 short tons, which was 7 per cent lower than May, 1956 and 9 per cent lower than June, 1955.

September 25

▲ Prices of steel scrap declined in Pittsburgh and Philadelphia with No. 1 heavy melting grade at $57 a ton in Pittsburgh, down $2 from the price following the steel strike early last month.

▲ Resistance Welder Manufacturers Assn. reported that shipments by its members in August, 1956 totaled $6,500,000, and new orders received during August amounted to over $5,000,000.

▲ The Aluminum Assn. reports primary aluminum production in the United States during August, 1956 was 184,812,424 lb, compared with shipments of 303,248,010 lb in July, 1956 and 267,081,664 lb in August, 1955. The lower shipments for August, 1956 reflects loss of production due to strikes.

September 26

▲ A 3-year contract was signed by the United Steelworkers and the American Can Co. that provides, effective October 1, 1956, wage increase of 7½ cents per hour, and further increases of 7 cents on October 1, 1957 and October 1, 1958; the contract also contains a cost-of-living escalator, improved insurance benefits, hikes in job-class increments, elimination of area, sex and salary differentials, 2¼ instead of double time for holidays worked, and improved vacation program.

▲ The Commerce Department removed refined copper export restrictions for the fourth quarter of 1956 due to increased domestic supplies of the material.

September 27

▲ Steel scrap prices further declined $1 to $2 a ton on some grades in Pittsburgh and Chicago.

September 30

▲ Prices of tin cans were increased an average of 3.7 to 4 per cent by American Can Co., Continental Can Co., and National Can Corp. because of wage increases granted the United Steelworkers and recent markups in tin plate prices.

IN A FEW HOURS ALL* OTHER ROTARY STRAIGHTENERS WILL BE OLD-FASHIONED !

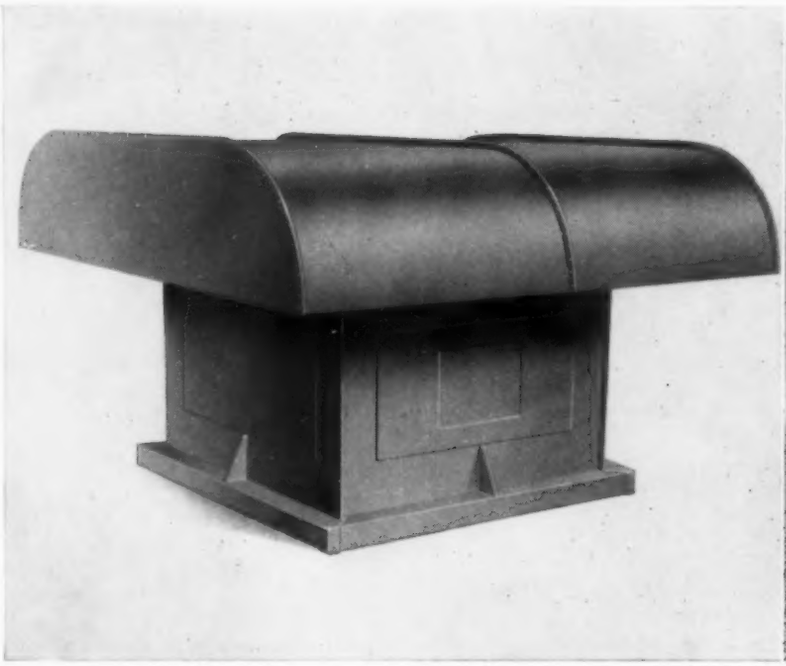
(*Excepting, of course, the 52 units of this type now in service.)

MANNESMANN-MEER Engineering and Construction Company, Inc., 900 Line Street, Easton, Pennsylvania

"Buffalo" SKY-VENT ROOF VENTILATORS

CAPACITIES: 1,000 cfm through 250,000 cfm

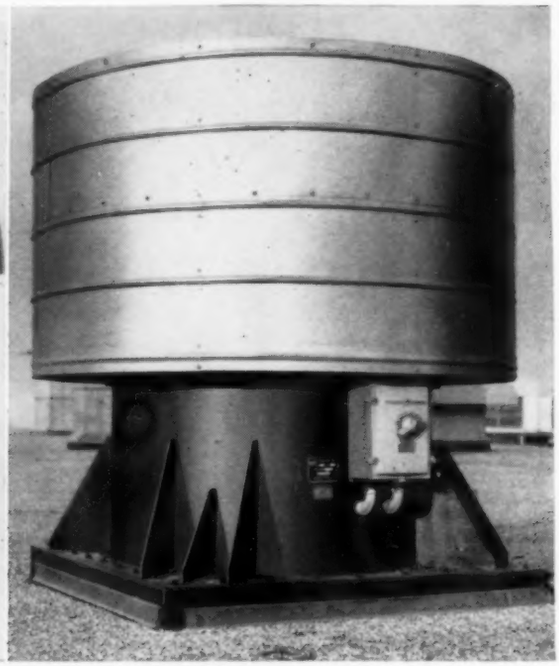
SIZES: 12" through 120"



Style "H" Sky-Vent

The Style "H" Sky-Vent head is made of heavy gage galvanized steel with integrally rolled stiffening flanges along its entire length and is internally braced with one-piece welded square hollow tubular frame. Hood design minimizes friction loss as air leaves unit.

The extra heavy galvanized steel stack with integral flanged curb plate has offset stiffening panels rolled into the side sheets and on larger sizes is further braced with one-piece welded square hollow tubular frame. Gravity, manual or motor operated shutters are available, mounted in the stack. Disconnect switch and internal wiring can be provided.



Style "V" Sky-Vent

Counterbalanced dampers open when fan starts, close by gravity over V-shaped trough at top of inner cylinder when fan is shut off. Heavy gage stack contains integrally welded gussets supporting motor and propeller fan. Outside gussets provide rigidity, minimize vibration. For easy installation, a flanged roof curbing plate is welded to the stack.

"Buffalo" high volume power roof ventilators are designed to ventilate large plant areas not adjacent to outside walls or where expensive and bulky duct work is impractical. This type of ventilation lends itself well to rearrangement of plant layout without consideration for the ventilating system.

The "Buffalo" Propeller or Axial Type Fan in the stack has all the strength, efficiency and smooth operation that characterizes the "Q" Factor* in all "Buffalo" Fans. Recently introduced, these new units are being adopted by many of the country's largest plants for removing hot air, fumes and fogs from large areas. Why not investigate? Write today on your company letterhead for Bulletin FM-1234 and other descriptive material.

The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

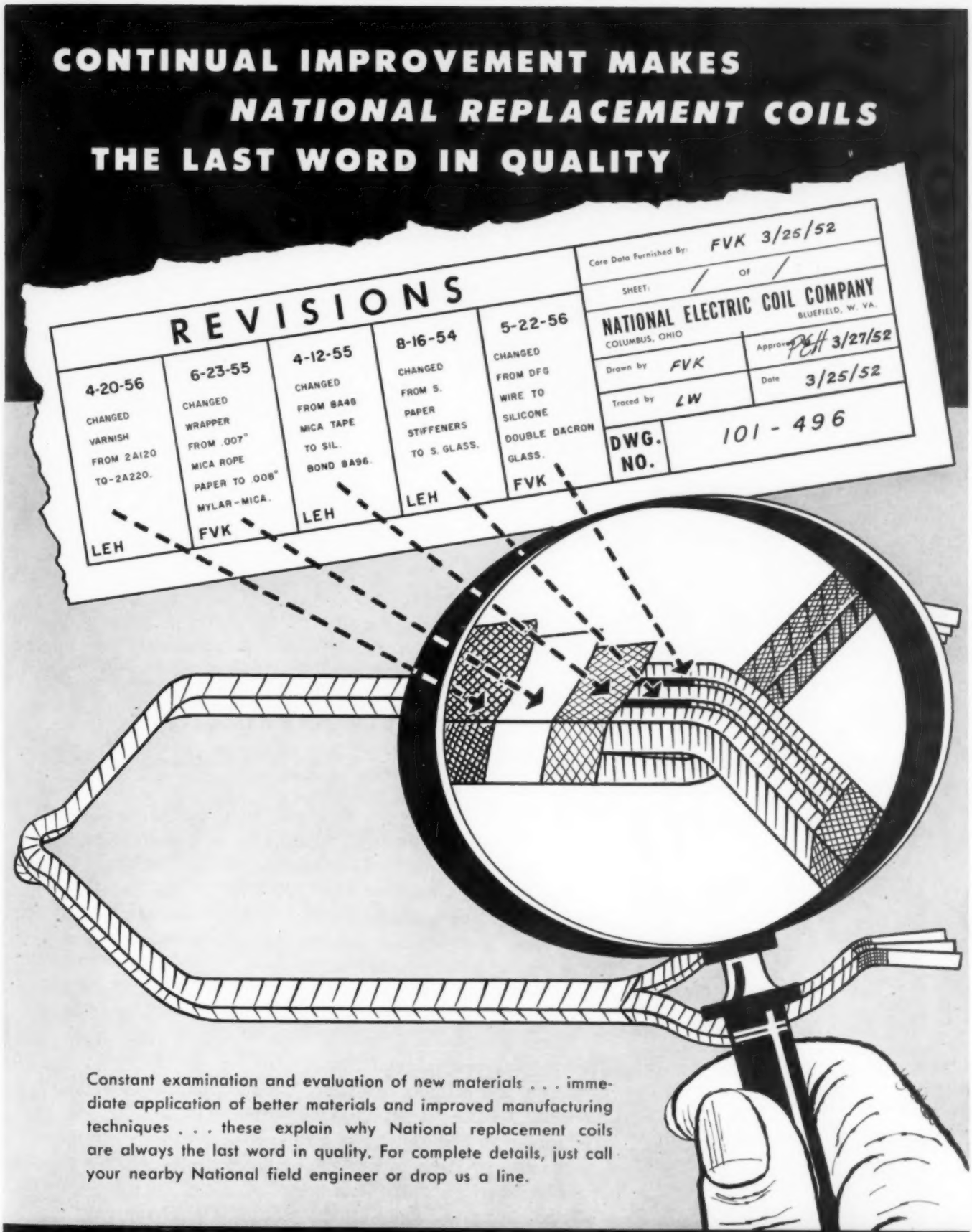
BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

INDUSTRIAL EXHAUSTERS **BELTED VENT SETS** **PROPELLER FANS** **"E" BLOWERS - EXHAUSTERS**

CONTINUAL IMPROVEMENT MAKES *NATIONAL REPLACEMENT COILS* THE LAST WORD IN QUALITY



Constant examination and evaluation of new materials . . . immediate application of better materials and improved manufacturing techniques . . . these explain why National replacement coils are always the last word in quality. For complete details, just call your nearby National field engineer or drop us a line.

NATIONAL ELECTRIC COIL COMPANY

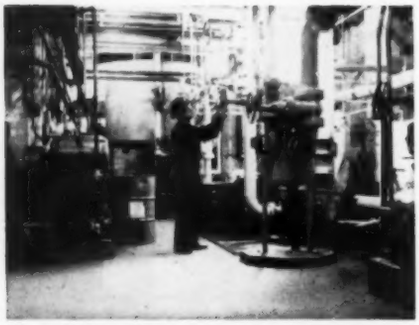
COLUMBUS 16, OHIO, U. S. A.

TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

Time exposure shows continuous motion of red-hot ingot as it travels through roller.

"Never replaced screwdown or nut using Cities Service E. P. Lubricants!"



Circulatir , System located on floor below mill, uses Cities Service E. P. Oils. Mill operates 160 hours a week, has never had lubrication failure.

Dial Gauges Accuracy to 1/32 of an inch. It is used by operators in the pulpit, who control the mill's 7000 horsepower and shape its steel to unusually fine tolerances for a blooming operation.

Ever since the installation of this blooming-slabbing mill at Pittsburgh Steel Company's Monessen Works, Cities Service E. P. Oils have been used for lubrication.

During that time, over 4,000,000 tons of steel have been run through the mill's huge rolls . . . but never once has the firm found it necessary to replace the screwdown, nut or any bearing due to lubrication failure.

A Pittsburgh Lubrication Engineer says: "Oils stay with the parts that must be lubricated and never give us a problem."

Where an inferior lubricant might be wiped away during the regular operation of the mill, Cities Service E. P. Oil withstands continuous operation. In addition, the oil can be centrifuged and yet not lose its additive.

Pittsburgh Steel is one of an increasing number of steel manufacturers who report outstanding results with Cities Service Lubricants. A Cities Service Lubrication Engineer will be happy to supply all the reasons. Or, if you prefer, write Cities Service Oil Company, Sixty Wall Tower, New York 5, New York.

CITIES SERVICE

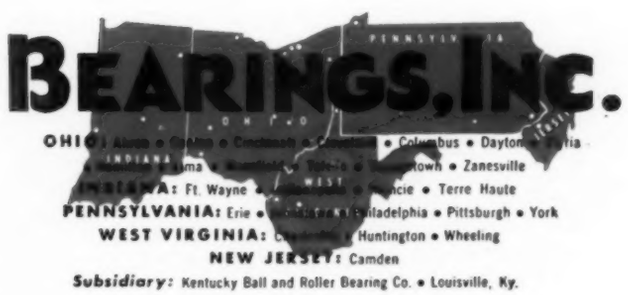
QUALITY PETROLEUM PRODUCTS

Make Certain the BEARINGS you buy are in the MAKERS' SEALED BOXES

And what is so important about a manufacturer's box? Just this: surplus bearings or shelf worn bearings are usually shipped in one large package. Or, if individually wrapped, in plain boxes — often without any identification, usually of ancient "vintage"... and bearings do not improve with age.

Bearings from Bearings, Inc. are **always** sold just as they arrive from the manufacturer — fresh, fully protected and guaranteed to be first quality by the maker and Bearings, Inc.

Bearings, Inc. is the authorized distributor for all of the many lines of bearings and accessories it sells. Our engineers can recommend the best bearing for your application. Call or return the coupon below.


BEARINGS, INC.
OHIO: Columbus • Dayton • Zanesville
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Subsidiary: Kentucky Ball and Roller Bearing Co. • Louisville, Ky.

BEARINGS, INC.
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Gentlemen:

I would like to know more about the lines you distribute.

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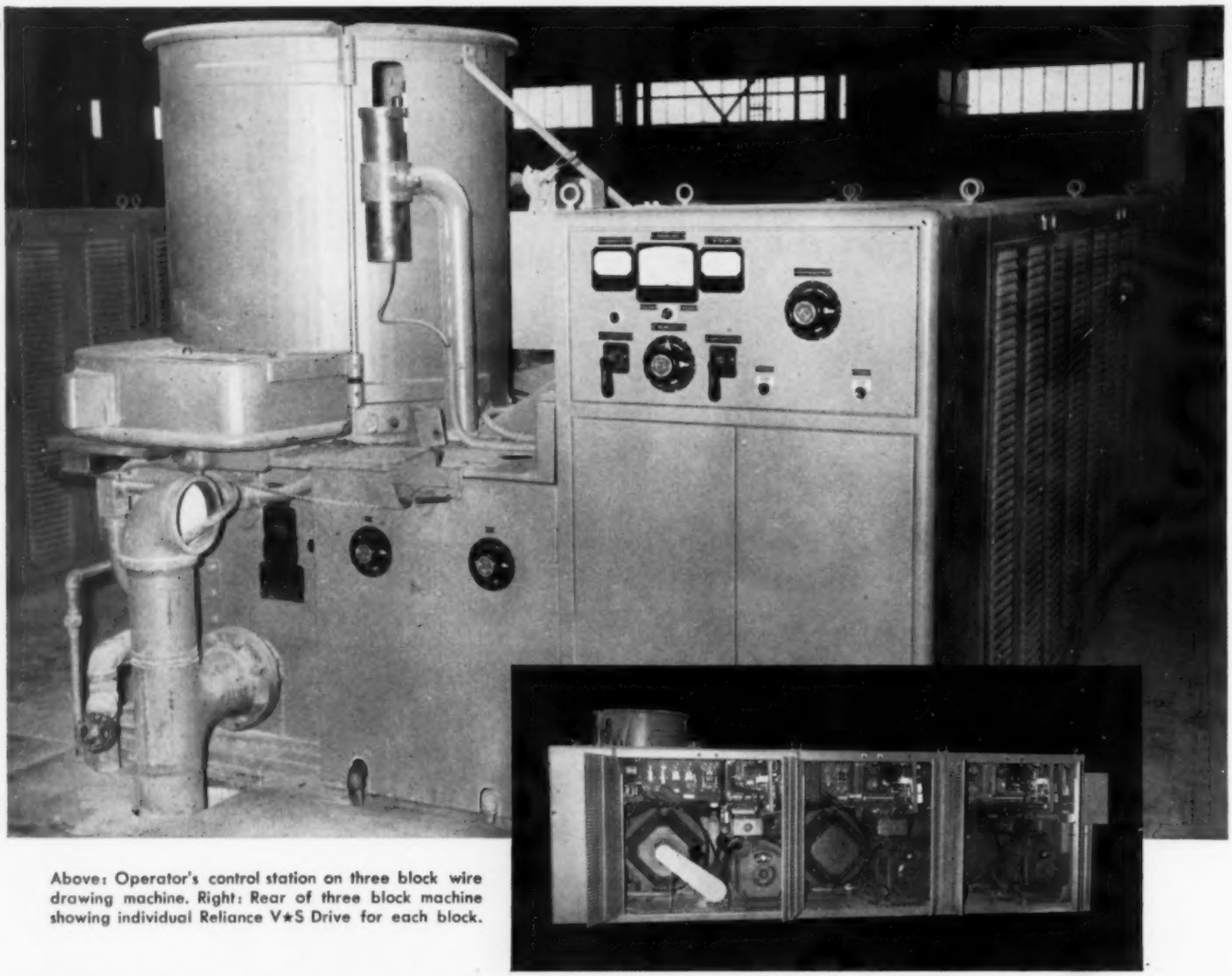

Above: Operator's control station on three block wire drawing machine. Right: Rear of three block machine showing individual Reliance V★S Drive for each block.

HIGH SPEED MOTO BLOX EQUIPPED WITH RELIANCE V★S DRIVES

With top machine speeds of over 4000 ft. per minute position control of block drives must be accurate and dependable. That is why Reliance V★S Drives are used on this type of cold drawing installation.

Converting power line a-c. to controlled d-c., the built-in V★S Drives individually control each capstan's speed. Yet all drives are interlocked to provide uniform machine speed and stop and start control.

This highly accurate drive system provides variable machine operating speeds from crawl speed to the record smashing 4000 ft. per minute. This span of operating speeds keeps the machine flexible, permitting the selection of the correct drawing speed for a wide range of wire diameters and types of steel.

Dependable, economical, Reliance V★S Drives are powering all types of steel finishing machines. Whether it's wire drawing machines or rolling mills, your best drive is a Reliance V★S Drive.

D-1581

May we send you our bulletin D-2311.

RELIANCE V★S DRIVE®

RELIANCE ELECTRIC AND ENGINEERING CO.

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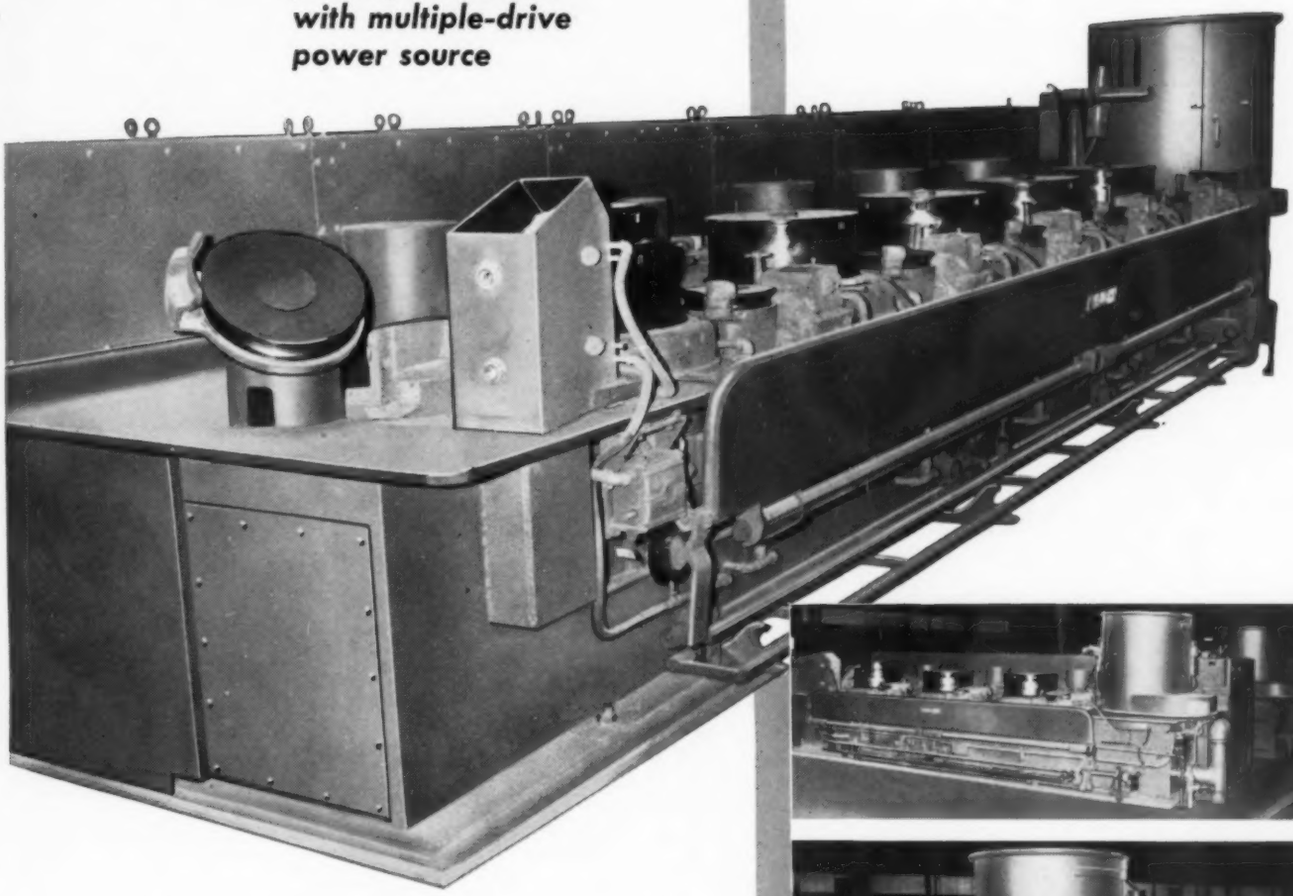
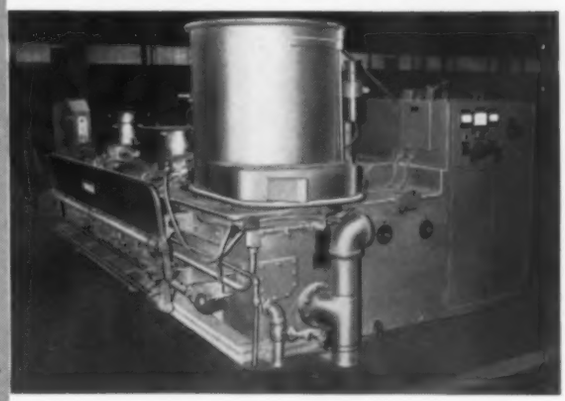
Here's something NEW in wire drawing

from VAUGHN®

pre-wired MOTOBLOX®

packaged complete with multiple-drive power source





The Vaughn Motoblox is now available with all electrical equipment (motor generator sets, starters and redesigned control circuit) packaged in one unit. Installation costs are substantially lower, and relocation of machine, if required, is greatly simplified.

Operational advantages include higher drawing speeds, greater stability, more flexibility and increased accessibility of electrical equipment for inspection and maintenance.

Yes—now more than ever VAUGHN IS "QUICK ON THE DRAW."

The VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U.S.A.

COMPLETE COLD DRAWING EQUIPMENT . . . Continuous or Single Hole . . . for the Largest Bars and Tubes . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

These advanced VAUGHN wire drawing units were displayed at the 1956 Cleveland Iron & Steel Exposition in the Reliance Electric and Engineering exhibits.

Ohio Rolls

shaping metal for all industry

Choose from 12 types of
Ohio Iron and Steel Rolls:

- Carbon Steel Rolls
- Ohioloy Rolls
- Ohioloy "K" Rolls
- Flintuff Rolls
- Holl-O-Cast Rolls
- Chilled Iron Rolls
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- Ohio Double-Pour Rolls
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THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO

Plants at Lima and Springfield, Ohio

OH4

Industry News...

ARMCO STEEL CORP. APPPLIES FOR CERTIFICATE OF NECESSITY COVERING SHEFFIELD EXPANSION

▲ Application has been made by Armco Steel Corp. to the federal government for a certificate of necessity covering a proposed $118 million expansion program at the Houston Works of the company's Sheffield Division.

The announcement was made by R. L. Gray, Armco president, who said that the proposed program is aimed primarily at increasing the company's output of heavy steel plate and structural shapes. It would also provide facilities for producing seamless tubing.

Large quantities of heavy plate and seamless tubing are used in the oil country of the Southwest and demand has outstripped current production he said.

He also announced that Armco has applied for a separate certificate of necessity covering a $5 million project to open a new coal mine near McAlester, Okla. The mining area which would be opened is already owned by Armco. Its reserves of high volatile coking coal are adequate to serve the needs of the company's Houston Works for many years to come, he said.

Describing the proposed Houston expansion, Mr. Gray said that the facilities covered by the application for the certificate of necessity would increase the basic steelmaking capacity of the plant, as well as provide the equipment to process the steel into the products in greatest demand in the Southwest.

Armco's plans call for the addition of a second blast furnace, a second battery of coke ovens, additional sintering facilities, three new 300-ton open hearth furnaces, a new slabbing and blooming mill, a mill for rolling tube rounds and alloy bars, additions to the present plate mill to step up production of heavy plates, a new seamless tube mill, and heat treating facilities for alloy bars and plates.

The application for the certificate of necessity also covers sintering facilities and an ore blending system already under construction.

Plans for the coal mine which Armco plans to open at McAlester include sinking a central mine shaft, providing an adequate water supply, and construction of complete facilities for coal screening and washing.

COMPLETES PURCHASE OF NEWPORT STEEL CORP.

▲ Acme Steel Co., under the provisions of a purchase agreement with Newport Steel Corp., has taken possession of the property and assets of the former Merritt-Chapman & Scott subsidiary.

Newport as a wholly owned subsidiary of Acme Steel will be operated as a new Illinois corporation under the name of Acme-Newport Steel Co. Present Newport Steel management will continue to administer the business with A. P. Miller as vice president and general manager, and Carl M. Riefkin as vice president in charge of sales.

Acme-Newport Steel Co. will continue to produce its present line of products, and these will be augmented by additional steel specialties.

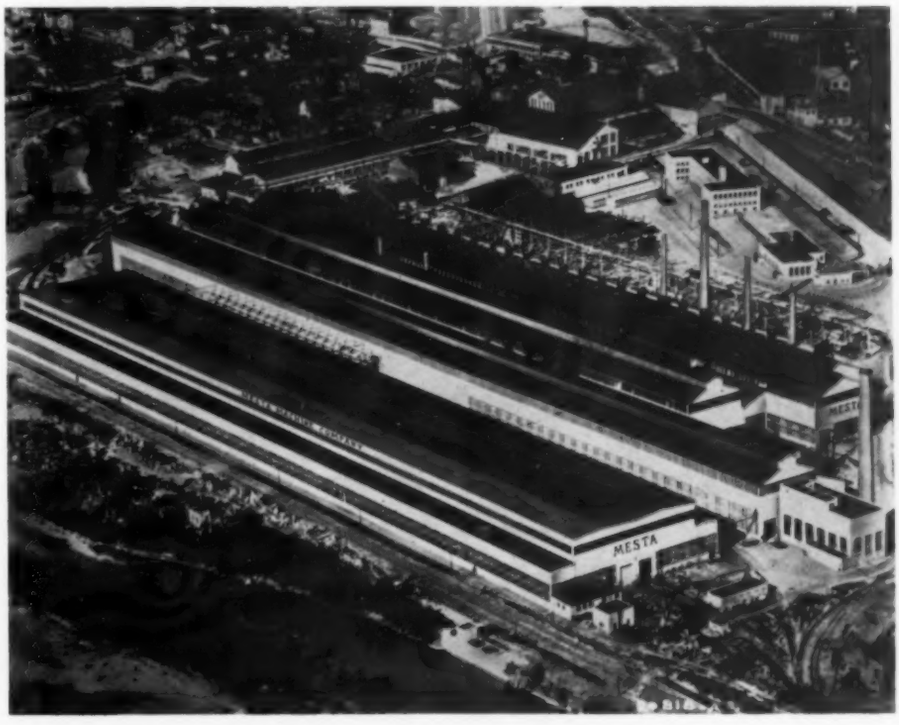
Sales of Newport Steel have been currently running at the rate of approximately $5 million a month whereas Acme Steel's have been around $10 million a month. The

MESTA PUTS NEW CASTLE PLANT INTO OPERATION

The Mesta Machine Co. is rapidly putting into operation the new New Castle Pa., plant which it recently purchased from the Government for about $8,000,000. This plant consists of a foundry and machine shop formerly operated by the United Engineering and Foundry Co. under lease from the Government for some years. Operations are being rapidly resumed by Mesta and the machine shop is in operation with castings shipped up from the Mesta plant at West Homestead. Two of the furnaces are going into operation in October.

The plant can produce steel castings up to 200 tons and has a machine shop equipped to machine and finish such castings. The plant is capable of producing all types of commercial steel castings and completed heavy machinery. There are four acid open hearth furnaces, one 35-ton, two 50-ton, and one 100-ton; seven casting pits, seven annealing furnaces, and all the necessary core ovens, blasting equipment, sand handling equipment, forge shop, and so forth.

Mesta plans to have a force at work of about 1200 in the near future and the plant should substantially better Mesta's rate of shipments of equipment.



Incomparable

for Making DENSE TIGHT JOINTS in Brickwork Linings of BLAST FURNACES SOAKING PITS ANNEALING FURNACES

Outlasts the brick it bonds

1. Has but a fraction of the iron content of other refractory bonding mortars, preventing carbon deposition.
2. Does not shrink or spall in the joints; has higher dried density than the brick itself; reduces channeling.
3. Strongest abrasion- and wear-resistant mortar on the market.
4. Has ideal heavy body and water-retention properties for best bricklaying practice on both ceramic and carbon brick.
5. Reduces downtime and maintenance labor and materials; increases productivity.
6. Unlike other mortars, Super #3000 has high bonding strength at low, medium and high temperatures.

REFRACTORY & INSULATION CORP.

R&I

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

136 WALL STREET • NEW YORK 5, N. Y.

combined annual sales for the companies should approximate $170 million a year, based on current operating rates.

AWARDED DUST CONTROL CONTRACT BY U. S. STEEL

▲ The United States Steel Corp. has awarded Western Precipitation Corp. the order for the largest system ever designed for control of open hearth dust and fumes. Western Precipitation will have the responsibility, in cooperation with U. S. Steel engineers, for the design of a complete gas cleaning system including the fabrication and installation of electrostatic precipitators for eleven open hearth furnaces located at U. S. Steel Corp.'s Homestead District Works. This project will represent a multimillion dollar expenditure for the control of air pollution.

The dust from all eleven furnaces will be collected in a main flue system and conducted to central gas cleaning stations comprising electrostatic precipitators of the latest design and type. When this project is complete this shop at Homestead Works will have a completely automatic air pollution control system operated from a central remote control station, providing push-button control of gas flow and dust removal.

UNVEILS PILOT PLANT TO CONTROL WASTE ACID

▲ The nation's first pilot plant for disposing of steel plant waste acid by the Blaw-Knox Ruthner process was unveiled September 17 at Republic Steel Corp.'s Niles Works. Witnessing the startup of the experimental unit were leading water authorities from an eight-state area.

The operation converts spent sulphate liquors into useful sulphuric acid and iron oxide. It is hoped this process will point the way to a solution of the problem of disposal of waste pickle liquor from the steel mills. The new process represents the steel industry's latest approach to a problem which has stubbornly resisted years of scientific study and research.

The Blaw-Knox Ruthner process was conceived by Othmar Ruthner, an Austrian scientist shortly after World War II. Blaw-Knox carried out a three-year program of exten-

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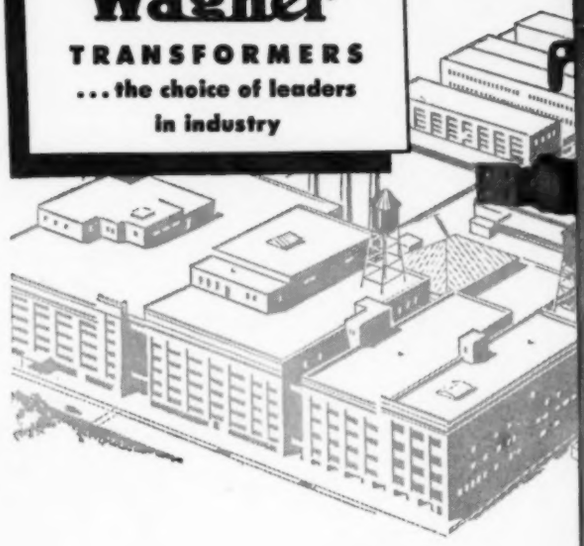
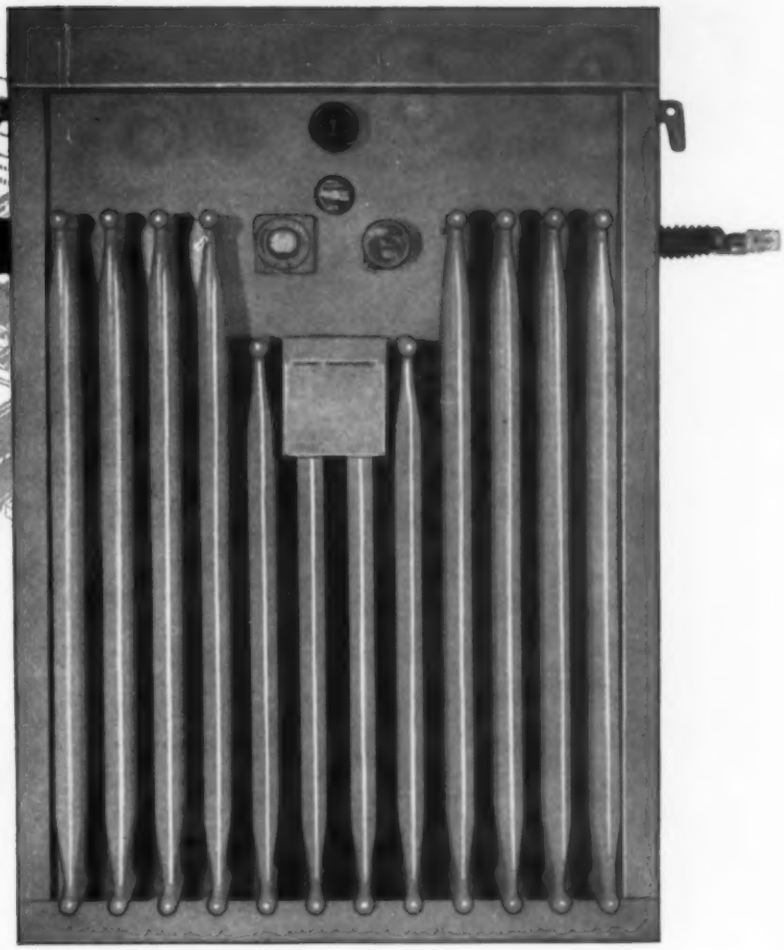
TRANSFORMERS
...the choice of leaders in industry





PLANNING A NEW LOAD CENTER?

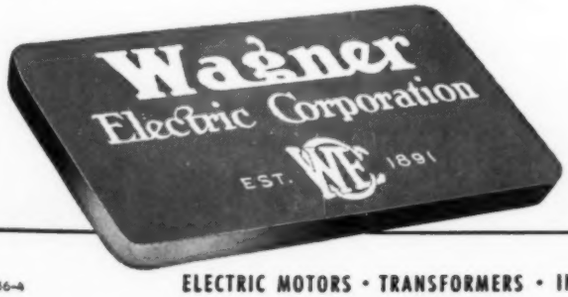
...with the Wagner Close-Coupled Transformer, you can build a compact, modern unit substation

These Unit Substation Transformers save space... make a neat, streamlined installation

Wagner close-coupled, liquid-filled unit substation transformers can be easily flush-mounted with co-ordinated switchgear. And when they are, the result is a neat, modern, compact installation that not only saves space in your plant, but looks better too.

You get quicker delivery on a close-coupled Wagner transformer because there are fewer engineering difficulties than with the throat-connected type. It's not necessary to co-ordinate the bushing height of a close-coupled unit to match special switchgear. Bushing heights are designed to give ample room to make connection to switchgear or busses in the switchgear compartment or transition section. No need for special throats to match special switchgear.

Look to Wagner for transformers that assure a continuous dependable flow of power. Your nearby Wagner engineer will be glad to help you solve your load-center problems. Call the nearest of our 32 branch offices or write us.



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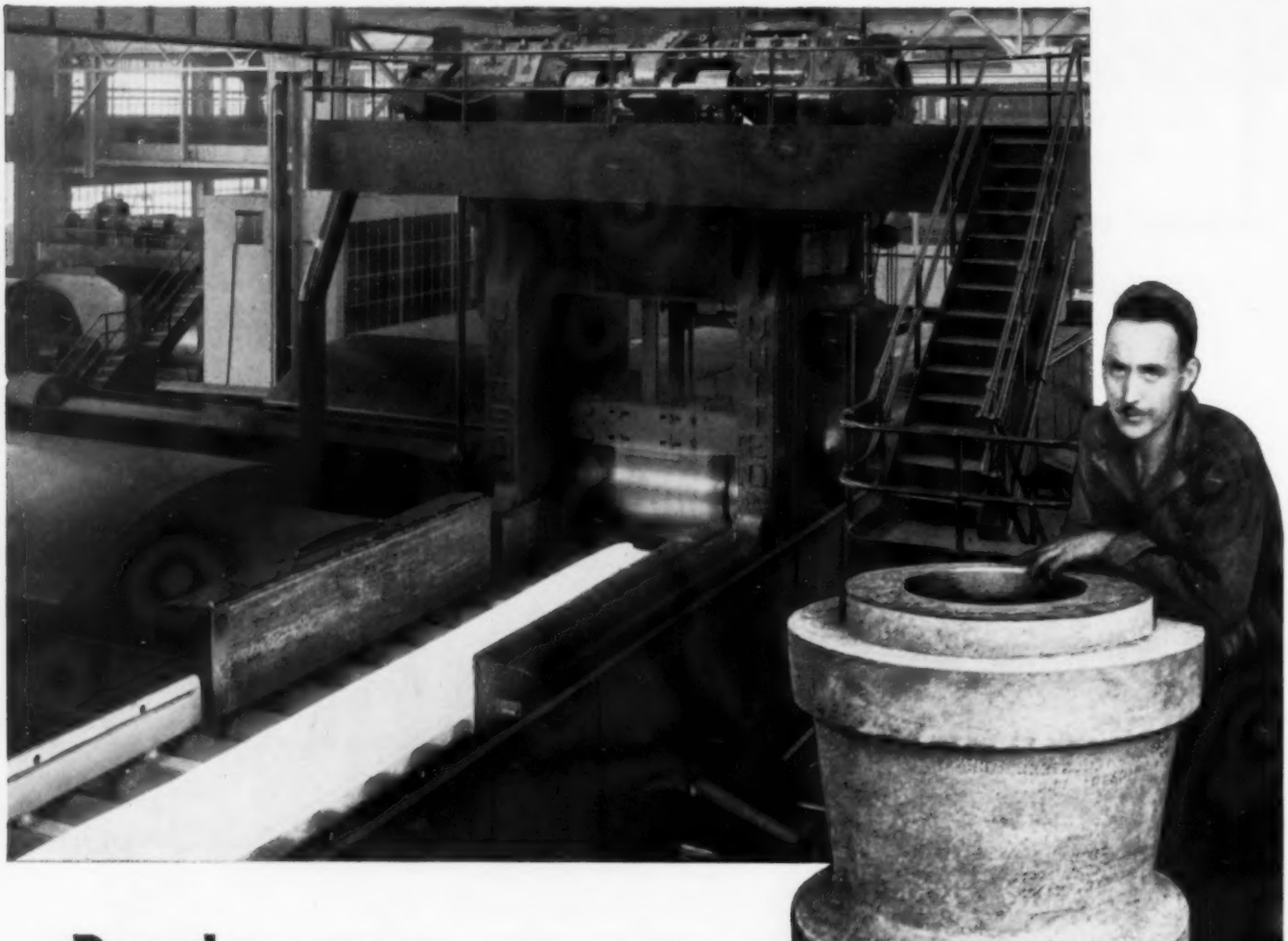
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS–AIR AND HYDRAULIC



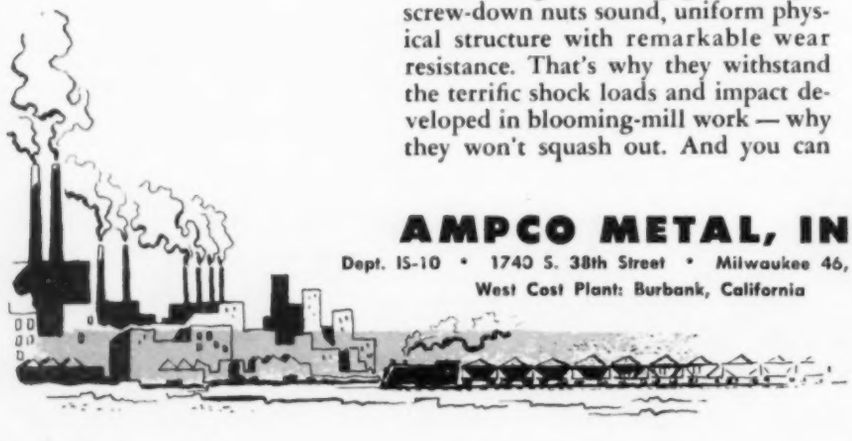
Put the squeeze on costs
Reduce downtime
...use AMPCO*
Screw-down Nuts

CUTTING costs is old stuff to Ampco Metal. And when Ampco is centrifugally cast into screw-down nuts for blooming-mills, you find no equal for top performance — lower costs — longer runs.

Centrifugal casting gives Ampco screw-down nuts sound, uniform physical structure with remarkable wear resistance. That's why they withstand the terrific shock loads and impact developed in blooming-mill work — why they won't squash out. And you can get Ampco screw-down nuts in sizes up to 6000 pounds.

Wherever extra toughness and wear resistance is important, you find Ampco Metal on the job — in slippers, wear plates, flash-welding dies. Its high resistance to corrosion saves money for you in pickling equipment and similar applications.

Your nearby Ampco field engineer is glad to give you full information. Contact him today or write us.



*Reg. U. S. Pat. Off.

AMPCO METAL, INC.

Dept. IS-10 • 1740 S. 38th Street • Milwaukee 46, Wisconsin

West Coast Plant: Burbank, California

AMPCO®

O-19

sive development to adapt the process to American standards and to determine the proper materials of construction. The half-million dollar pilot plant is sponsored by B'aw-Knox Co., Jones & Laughlin Steel Corp., National Steel Corp., Pittsburgh Steel Co., Republic Steel Corp., United States Steel Corp., Wheeling Steel Corp., and Youngstown Sheet & Tube Co.

Robert H. Ferguson, Chairman of the sponsors' committee, called the pilot operation "another significant contribution to the nation's search for improved water supplies." He emphasized that "the industry has made great strides in the control of waste materials and we hope the tests which will be conducted here will unlock the door to one of industry's most stubborn disposal problems."

H. K. PORTER CO., INC. ACQUIRES W. VA. STEEL

▲ The business of West Virginia Steel and Manufacturing Co., Huntington, W. Va., has been acquired by H. K. Porter Co., Inc. Announcement was made by B. Campbell Blake, vice president and general manager of Porter's Connors Steel Division, with which division the operations of the new plant will be combined. Sales of the newly acquired concern are currently at the rate of $18 million annually.

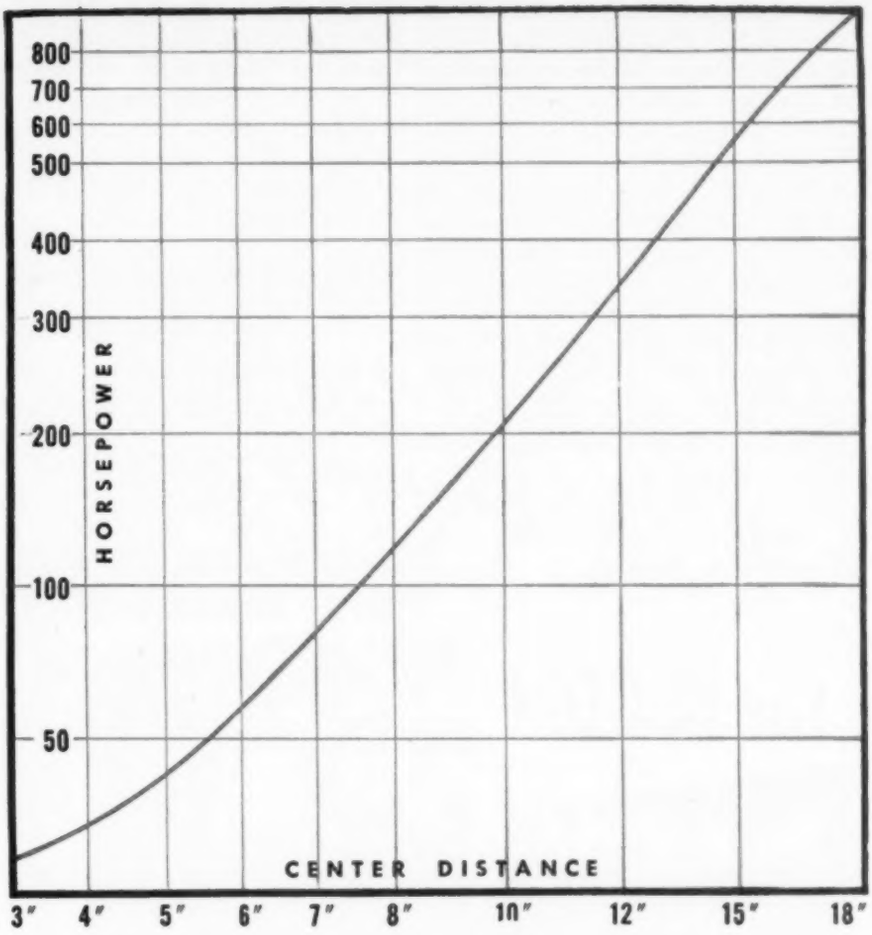
West Virginia Steel, with offices and plant in Huntington, was founded in 1907. J. J. Durkin, West Virginia's executive vice president will continue to supervise operations at Huntington.

West Virginia Steel melts and rolls electric furnace steel and rails. Its products include light steel rails, reinforcing bars, mine roof bolts, hot rolled bars and semi-finished steel. Porter plans to expand the West Virginia operation.

TO FABRICATE OXYGEN CONVERTER FOR KAISER

▲ A contract has been awarded to Pennsylvania Engineering Corp. by Kaiser Engineers, Division of Henry J. Kaiser Co., to fabricate the third installation of top blown oxygen steel converters to be built in this country.

This job, involving two 65-ton ca-



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

. . . because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact ovet a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division, Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

pacity oxygen steel vessels, including stands, tilting drives, and auxiliaries, is to be one of the key elements in the large expansion program now under way at Kaiser Steel Corp., Fontana, Calif.

The two earlier installations of oxygen converters were also fabricated by Pennsylvania Engineering Corp. The first units for McLouth Steel Corp. have been in operation since 1954, and two 65-ton units are now under construction for Kaiser Engineers for installation at the Aliquippa Works of Jones & Laughlin Steel Corp.

It is contemplated that the Kaiser Steel units will be designed and built with one piece shells. Before being shipped to the erection site, the units will be fitted up in Pennsylvania Engineering shops, match marked and photographed to simplify field erection and insure accuracy.

AWARDS PICKLING LINE CONTRACT TO MESTA

▲ A contract covering the design and manufacture of a 48-in. continuous pickling line for the Sparrows Point plant of the Bethlehem Steel Co. has been awarded to Mesta Machine Co. The unit will be designed to pickle coils of hot rolled mild carbon steel strip up to 44 in. wide.

The entry end of the pickling line will be geared for a speed of approximately 1,200 to 1,400 fpm with capacity for handling coils up to 56 in. in diam, and weighing up to 500 lb per in. of width. The equipment at the delivery end of the line will be geared for a speed of approximately 600 fpm and designed to deliver coils with maximum diameter of approximately 73 in. weighing as much as 1,000 lb per in. of width.

The equipment will include pickling tanks totaling 330 ft long; a combination processor and straightener; two shears; and an electric flash welder to join the coils.

Mesta will be responsible for the complete layout, will make all the engineering details required for the construction of foundations and electrical systems, and will supervise the work of installation in the field.

TO SUPPLY LUBRICATION SYSTEM FOR FOIL MILL

▲ Dravo Corp. will supply a mill lubrication system for installation on an aluminum foil mill for the Kaiser Aluminum and Chemical Co., now under construction at Ravenswood, W. Va.

A Dravo-DeLaval custom-designed unit will lubricate Morgoil bearings on the 10-in. and 34-in. by 72-in. four-high mill, which will have an output of 4000 ft of foil per minute. The lubrication system will have a metered flow of 54 gallons of 900 SSU oil per minute at a temperature of 100 F.

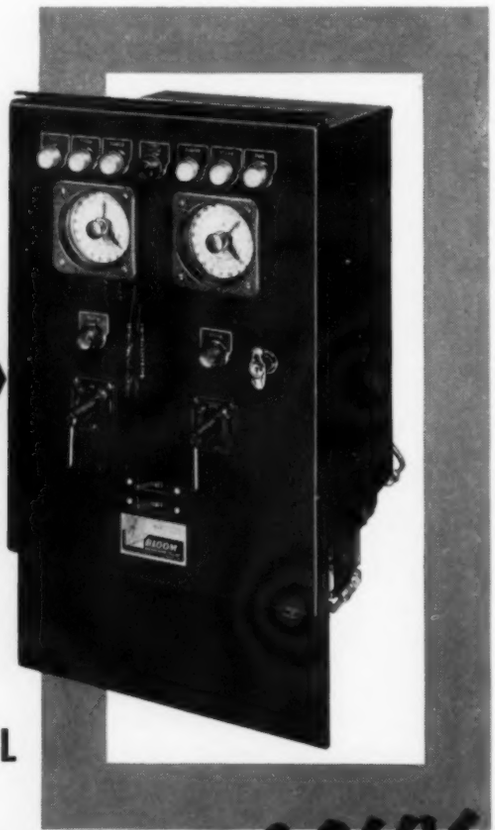
The lubrication system equipment was ordered by the Loewy Hydropress Division of Baldwin-Lima-Hamilton Corp., designers and builders of the mill for Kaiser.

ANNOUNCES LEASING OF IRON ORE DEPOSIT

▲ Jones & Laughlin Steel Corp. announced that it has leased for purposes of tests and study a large iron ore deposit six miles from Kirkland Lake, Ontario, in Canada. The firm believes that adequate reserves are available to support a mining and beneficiating plant on the property.

The property was leased by J&L

The BLOOM Time-Cycle Reversal Unit

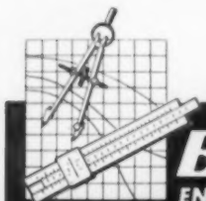


assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY

This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It elimnates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.



BLOOM ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

* Sintering Plant at a Major Steel Company...

Four years without fan replacement since installing

WESTERN PRECIPITATION CMP EQUIPMENT!

The steel industry's sintering plants have a double-barreled reason for installing the most efficient equipment available for dust recovery . . . (1) elimination of air pollution, and (2) reduction of fan wear. And the best indicator of collector efficiency is to watch for fan wear, because *negligible fan wear means negligible dust, minimum air pollution!*

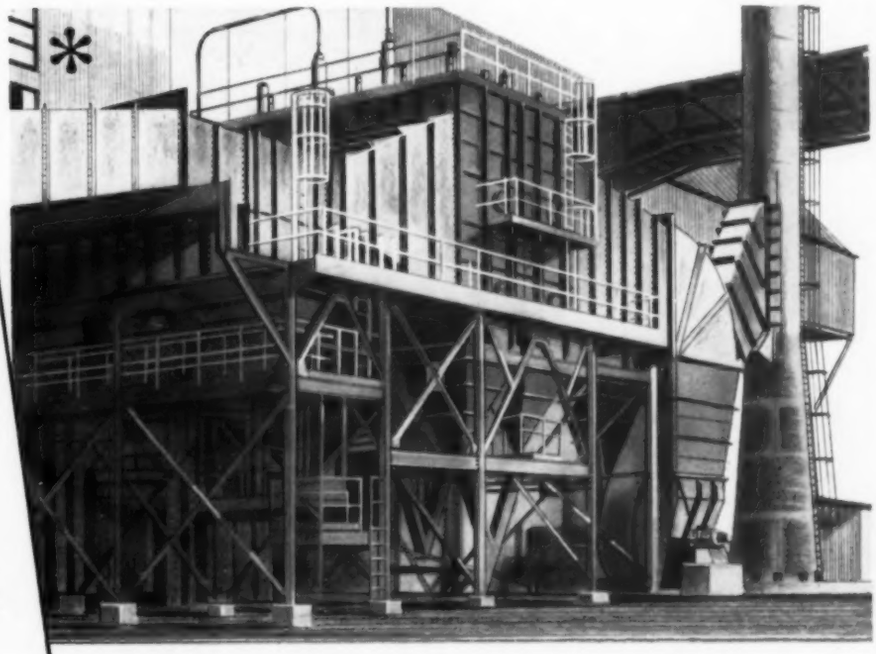
The experience of one major eastern steel company is particularly significant. Since installing Western Precipitation CMP Units four years ago, it has not been necessary to replace or repair a single fan in the plant systems these units serve.

Moreover, this CMP equipment has proven so satisfactory that this same company has ordered and reordered additional installations. *To date, six CMP installations are either already in service or are on order for this one plant!*

The CMP is another product pioneered by the industry's most experienced organization in dust, fume and fly ash recovery—Western Precipitation Corporation. Backed by Western Precipitation's years of know-how in both *electrical* (Cottrell) and *mechanical* (Multiclone) recovery principles, the CMP (Combination Multiclone - Precipitator) combines advantages of *both* these basic types into *one* compact coordinated unit. The Multiclone section mechanically separates all but the very finest suspended particles, and then the Cottrell section provides final clean-up with electrical ionization.

Result:

Unusually high recovery efficiency at low installation and maintenance costs. Best of all, there is no "transfer wear" from sintering plant fans to recovery equipment, for CMP maintenance requirements are negligible.



No matter what your recovery requirement, the know-how of the industry's most experienced organization in dust, fume and fly ash recovery is at your service. We are equipped to handle installations on either a complete "turnkey" basis, or supply equipment only, whether electrical (Cottrell), mechanical (Multiclone), filter (Dualaire)—or combination systems.

Throughout the major industrial areas of United States and Canada, there's a Western Precipitation office as near as your telephone. May we place this unequalled know-how at your service?

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases
..and Equipment for the Process Industries

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Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

Representatives in all principal cities

from the Dominion Gulf Co., a subsidiary of Gulf Oil Corp. No plans for development of the property have been announced by J&L.

Since announcing its option of the property in 1954, J&L has drilled the deposit to prove the presence of magnetic taconite ore in the area. Laboratory tests conducted on samples of the ore have developed an economic process of concentrating the taconite to a usable blast furnace ore.

When production is begun, at a date not yet set by J&L, the ore will be mined by open-pit methods; crushed; and concentrated magnetically to produce a high-grade product. The concentrate will be pelletized before being shipped to the steel plants.

J&L said that the property will be held as an idle reserve until additional supplies of iron ore are needed.

COMPLETES FURNACE FOR ITALIAN COMPANY

▲ Completion of its sixth 220 metric ton basic open hearth furnace for Cornigliano, S.p.A., at Genoa, Italy, is announced by Loftus Engineering Corp. The actual construction of the furnaces was done with Italian craftsmen, working with the supervision of Loftus field engineers.

Loftus, through its associate, Friedrich Kocks G.M.B.H., has another contract in Italy, this one for two 180 metric ton open hearth furnaces to be constructed at the Ilva Piombino plant of Finsider.

In the new integrated steel plant now being built on the tide water of the Wesser River by Klockner-Werke, A.G., near Bremen, Germany, furnaces of Loftus design are also being installed. In addition to the open hearths, nine ingot heating furnaces have been designed by Loftus for this new Bremen plant. These ingot heating furnaces are capable of heating 140 metric ton charges, using straight preheated blast furnace gas, or fuel oil.

Four 250 metric ton open hearth furnaces designed by Loftus are now being installed in the August Thyssenhutte Steel Plant, Driesburg Germany. Loftus has also furnished consulting services to modernize the open hearth auxiliary equipment at this plant.

AWARDS CONTRACT TO WESTINGHOUSE

▲ Orders totaling almost $4 million covering electrical equipment for the Tata Iron & Steel Co. mills at Jamshedpur, India, have been placed with Westinghouse Electric Corp. by Kaiser Engineers.

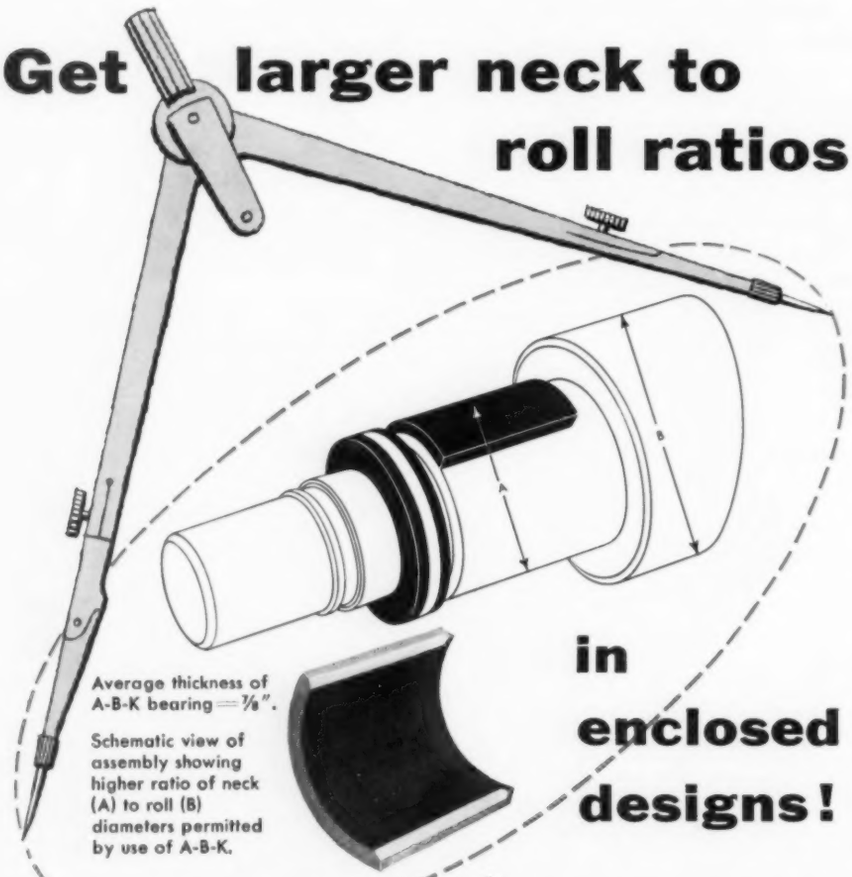
The engineering firm has been awarded a contract to design, construct and equip a $130 million expansion of present manufacturing facilities at Jamshedpur.

Westinghouse equipment will completely electrify a medium and light structural steel mill and provide auxiliary direct current electricity for two other mills.

DELTA-STAR OPENS NEW BRANCH OFFICES

▲ Delta-Star Electric Division, H. K. Porter Co., Inc., has opened new branch offices in Los Angeles, Calif., Birmingham, Ala., and Pittsburgh, Pa., according to an announcement by J. A. Romano, General Sales Manager. The new offices will serve in the

Get larger neck to roll ratios in enclosed designs!


Average thickness of A-B-K bearing = 1/8".
Schematic view of assembly showing higher ratio of neck (A) to roll (B) diameters permitted by use of A-B-K.

use A-B-K* bearings

No need to sacrifice roll neck diameters to keep down size and cost of bearing assemblies and housings. A-B-K bearings save space, permit larger, stronger roll necks—with cheaper, lighter weight parts. A-B-K laminated phenolic bearings have ability to absorb and cushion heavier impacts, and often outwear metal, many times. Grease and oil can be used for lubrication but water, alone, is often the answer. Ask our engineers for specific recommendations.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A-B-K LAMINATED PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

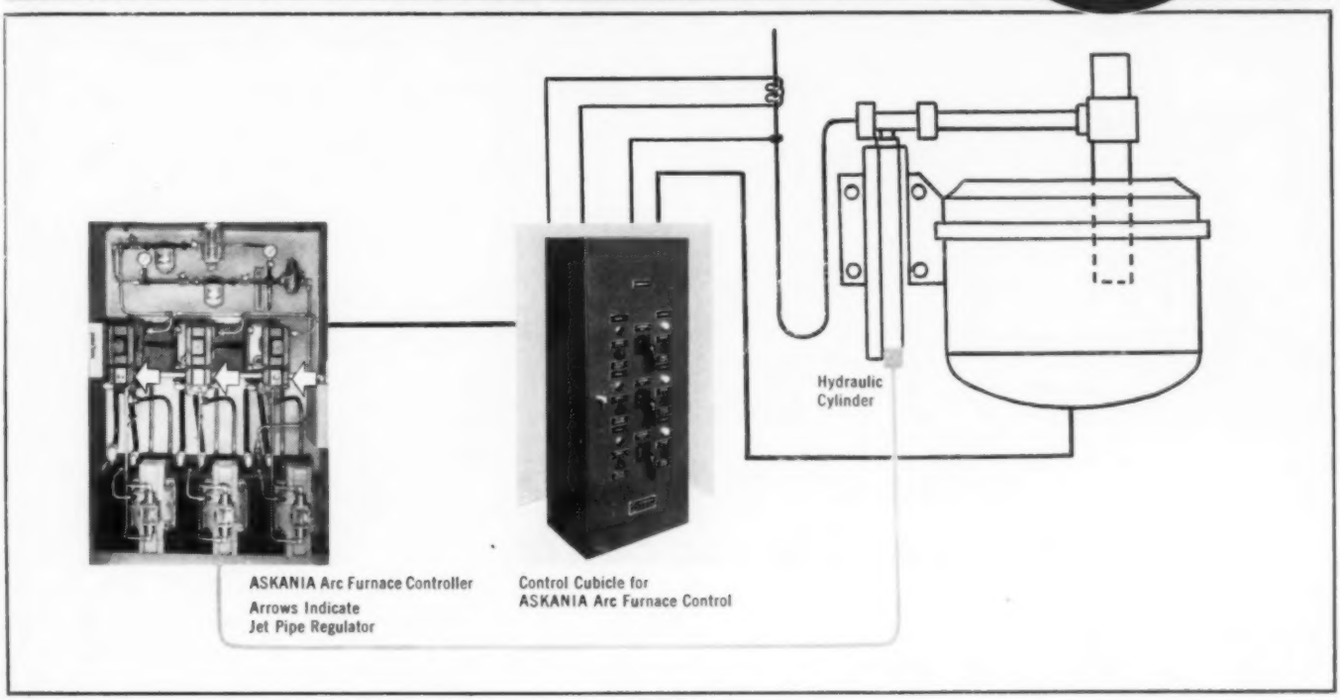
Brake Shoe

AMERICAN BRAKEBLOK DIVISION
Detroit 9, Michigan
In Canada: Joseph Robb & Co., Ltd., Montreal, Quebec

ASKANIA STEEL MILL CONTROL NEWS

Automatic Controls for
COMBUSTION • PRESSURE • FLOW •
STRIP EDGE POSITION • STRIP THICKNESS

ASKANIA JET PIPE FOR DEPENDABLE CONTROL


Hydraulic Cylinder
ASKANIA Arc Furnace Controller
Arrows Indicate Jet Pipe Regulator
Control Cubicle for ASKANIA Arc Furnace Control

ASKANIA Arc Furnace Control for Faster, More Accurate, More Dependable Control of Electrodes

With ASKANIA Arc Furnace Control voltage and current signal measurements are converted directly into electrode movement through the mill-proven ASKANIA Jet Pipe Relay...*to correct any imbalance with the speed and stability of proportional speed floating control.*

Electrically, the ASKANIA Arc Furnace Control balances arc current and voltage to maintain preset power input as determined by the operator.

CONTROL ADVANTAGES

1 • *FAST*—Takes full advantage of non-compressible hydraulic fluid to accelerate or decelerate heavy loads—through zero.

2 • *ACCURATE*—High force inertia ratio of hydraulic motor (piston) *permits high performance without overshooting.*

3 • *DEPENDABLE*—Proven ASKANIA design reduces number of moving parts. Self-lubricating, it may be operated in most unfavorable atmospheric and temperature conditions *without expensive and space consuming protective shelters.*

4 • *EASILY, INEXPENSIVELY MAINTAINED*—The force balance system contains only one moving part in the regulator (the Jet-Pipe Relay). Even after periodic inspection is made factory calibration is easily maintained after reassembly.

5 • *PEAK PERFORMANCE*—Advanced signal system reduces mass and consequently inertia to further improve performance.

New Descriptive Bulletin Provides Complete Information

The new ASKANIA REGULATOR Bulletin #33.2 fully describes the ASKANIA Arc Furnace Control...what it is...how it works...where it is applied...how it is maintained...the advantages it brings to arc furnace operation. Write for your copy to Askania Regulator Company, 246 E. Ontario Street, Chicago 11, Illinois.

ASKANIA REGULATOR COMPANY
"CONTROLS FOR INDUSTRY"
HYDRAULIC, ELECTRONIC CONTROLS & SERVOS, GENERAL SYSTEMS, ENGINEERING & COMPUTER SERVICE, VALVE ACTUATORS & CYLINDERS
A SUBSIDIARY OF GPE

Look Overhead... see "NORTHERN"

these notable twins assure dependability

LOCATION Press bay of a large, new plant manufacturing rear axle parts and components for automobiles and trucks.

SPAN 96 feet 10 inches, centers of runways.

CAPACITY 30-tons on Main Hooks, 10-tons on auxiliary hooks.

ELECTRICAL EQUIPMENT 60-HP motors on Main Hoist, Auxiliary Hoist and Bridge Travel, and 15-HP motor on Trolley Travel, with full magnetic control and direct current on brakes.

ADVANTAGES These twin NORTHERN cranes serve twin heavy press lines located at each end of the press bay. Designed for heavy duty requirements with compensating type bridge end trucks, and equally suitable electrical equipment and controls, they dependably and safely speed machinery installation or relocation, and assure smooth, uninterrupted flow of work in today's and tomorrow's automated production.

Let us explore similar possibilities in your plant

NORTHERN MATERIAL HANDLING EQUIPMENT

NORTHERN ENGINEERING WORKS
210 CHENE ST., DETROIT 7, MICH.

combined sales activities of Delta-Star and H. K. Porter Co.'s acquisition, the Electric Service Works, formerly the Electric Service Co. of Philadelphia, Pa.

G. A. Palka will be in charge of an office in the Broadway Arcade Bldg., 542 S. Broadway—Room 402, Los Angeles 13, Calif. L. S. Belding will supervise an office in the American Life Bldg., 2308 Fourth Ave. North —Room 205, Birmingham 3, Ala. J. F. Zboyovsky has been appointed district manager, and H. L. Cadwallader, assistant district manager of an office in the Grant Bldg., 330 Grant St.—Room 525, Pittsburgh, Pa.

J&L WILL BUILD NEW LOUISVILLE WAREHOUSE

▲ A 10-acre tract of land near Louisville, Ky. has been acquired by the Jones & Laughlin Steel Warehouse Division for the construction of a new warehouse. Plans are being prepared for a modern, full-time steel warehouse which will materially increase the scope of the operation of the present J&L warehouse in Louisville.

Enlarged inventories of structurals, plates, hot rolled bars, and cold finished steel bars will be carried at the new location. A flat rolled coil and sheet department will be added. Facilities for slitting, shearing, and processing—with equipment of the latest design—will be incorporated in the new operation.

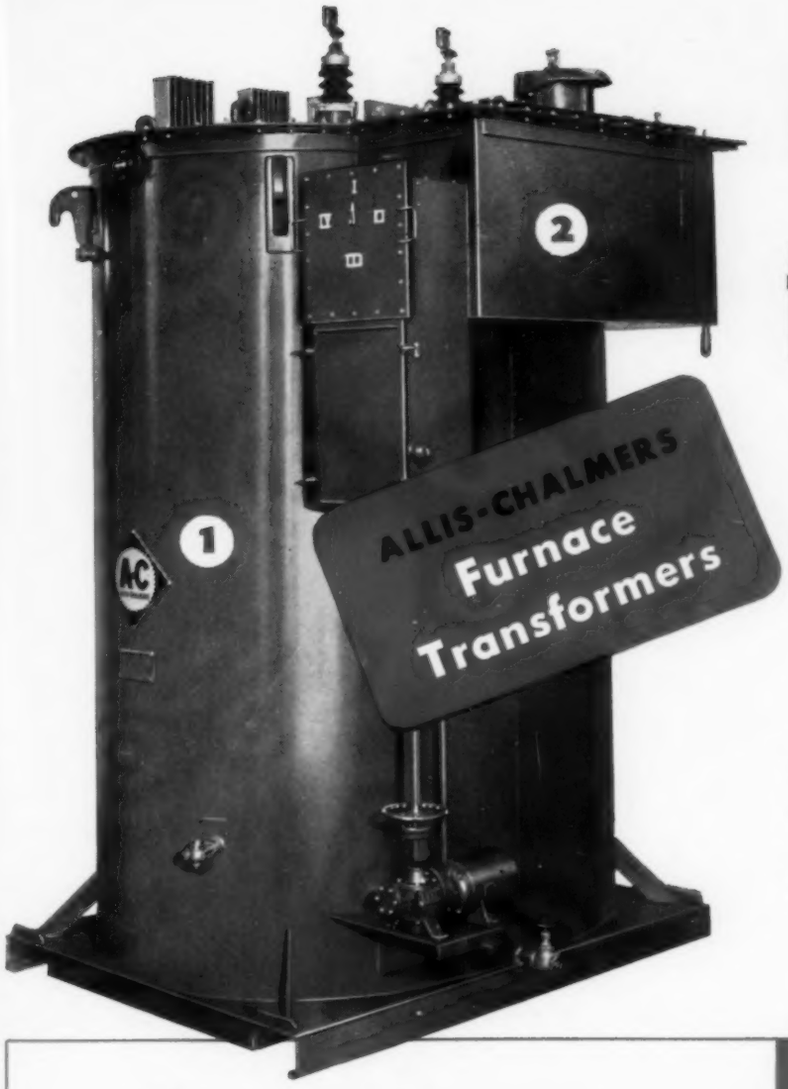
Meetings

▲ The Fall Meeting of The Galvanizers Committee sponsored by the American Zinc Institute, Inc., will be held at The Royal Connaught Hotel, Hamilton, Ontario, Canada, on October 25 and 26, 1956.

▲ The semi-annual meeting of the American Gear Manufacturers Association will be held October 28-31 at the Edgewater Beach Hotel, Chicago, Ill.

▲ The Gray Iron Founders Society, Inc., will hold its annual meeting Oct. 30-Nov. 2 at The Homestead, Hot Springs, Va.

▲ The 11th Annual Technical & Operating Conference of the Steel Founders' Society of America will be held at the Carter Hotel, Cleveland, Ohio, November 7, 8, 9, 1956.



4 Extras for Tough Jobs

Check features based on over 30 years' experience building arc furnace transformers

Features like these help Allis-Chalmers arc furnace transformers stand up under strain of repeated daily short circuits . . . the heat of high continuous currents . . . the corrosive atmosphere of the plant.

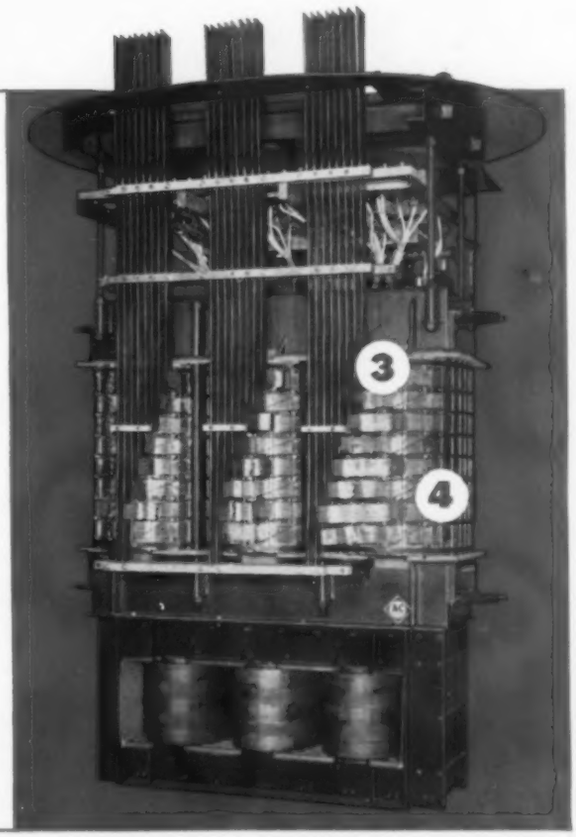
Extra Features —

1 ***EXTRA*** **SURFACE PROTECTION** — Grit blasting and three coats of baked-on alkyd resinous paint guard transformers against industrial corrosion.

2 ***EXTRA*** **ACCESSIBILITY** — Separate compartment for tap changer mechanism facilitates periodic inspection and maintenance.

3 ***EXTRA*** **STRENGTH SUPPORTS** and structure brace coils against severe short-circuit stresses.

4 ***EXTRA*** **PROTECTED WINDINGS** — Special insulation techniques protect winding from overvoltage due to wide tap range.



Complete Line of Arc Furnace Electrical Equipment Allis-Chalmers builds arc and submerged arc furnace transformers of all sizes, plus electrical control, circuit breakers and auxiliary transformers. For help on your problem, call your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-5086

ALLIS-CHALMERS

LIVE BETTER ELECTRICALLY

When you need naked bearings...or ...*bearings dressed up in overalls ready to go to work*, you can get anything and everything you require--in a hurry--from Berry Bearing Company.

As authorized stock carrying distributor for 41 of the leading makers of bearings and bearing specialties--with more than 50,000 items in stock--Berry can give you immediate delivery on any type...and...any size of bearing or transmission appliance you want. You name it--you can rely on Berry to deliver it--**FAST.**

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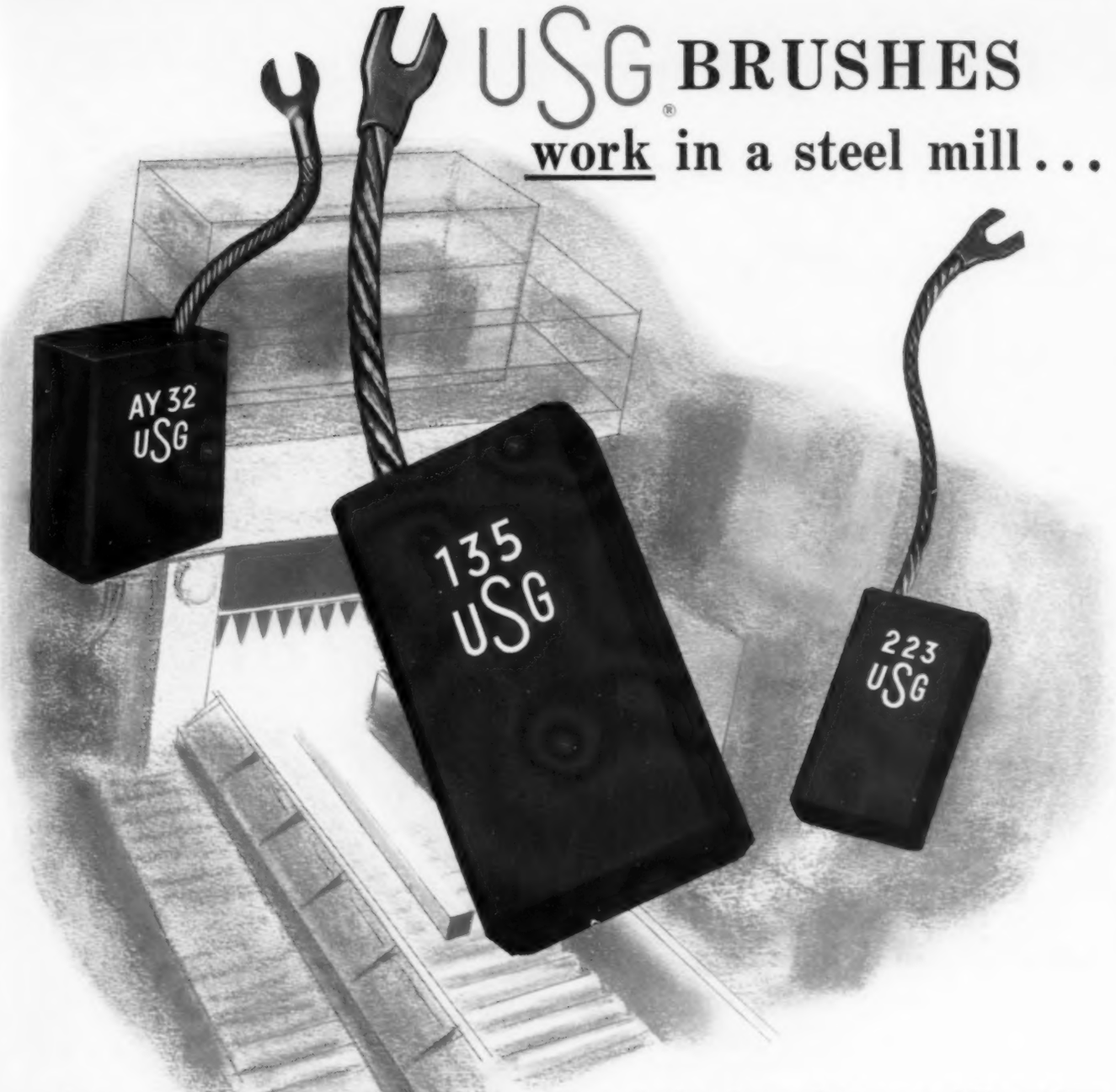
USG® BRUSHES
work in a steel mill...



for every Steel Mill job—the right brush* specification

THE JOB	THE BRUSH
Mill Motors	USG Grade 135
DC Crane Motors	USG Grade 223
Diesel Main Generators	USG Grade AY 32 or 2306
Diesel Switcher Traction Motors	USG Grade 2207
Welding Generators and Exciters	USG Grade AH 897
Tin Line Collector Rolls	USG Grade 1658
Tin Line Generators	Grade on request
Cleaning Line Generators	Grade on request
DC Generators (DC Power Supply)	USG Grade 232
AC Crane Motor Slip Rings	USG Grade 550

*All USG brushes can be obtained with STATITE®, the permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

Write for your copy of the complete USG Brush Catalog.

211

THE UNITED STATES GRAPHITE COMPANY
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Traveling Stocking and Reclaiming Coal Handling Tower OF WELDED DESIGN

a Mead-Morrison development

All connections in the main structure of this tower, both shop and field, are welded. The cantilevers employ riveted connections and are fastened to the main structure by means of rivets.

This modern design is typical of Mead-Morrison pioneering in developing stronger and more economical material-handling equipment. Write for complete information on Mead-Morrison Towers and Bridges for coal, ore and other materials.

Coal is brought to the plant of a large West Virginia steel mill in cars which dump into a digging pit alongside the Mead-Morrison tower. Unloading of the cars is aided by a car shakeout suspended from the side of the tower.

The tower digs coal from the trough and delivers it to the near-side stocking pile at the rated capacity of 915 tons per hour, and to the far-side stocking pile at the rated capacity of 610 tons per hour.

The tower also reclaims coal from the storage piles to the receiving hopper in the tower at the rated capacity of 765 tons per hour from either pile.

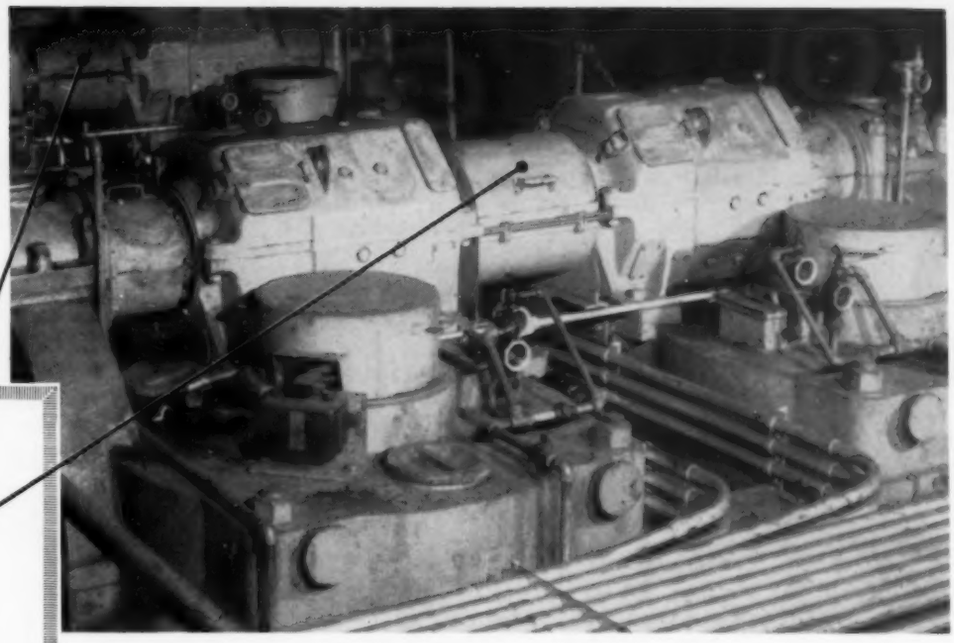
Included in the Mead-Morrison equipment are a 6½ ton lightweight grab bucket and automatic rail clamps to protect the structure in a high wind. Adjustable voltage is used for the hoist, close and trolley motions, and constant voltage for the propelling motors.

MEAD-MORRISON

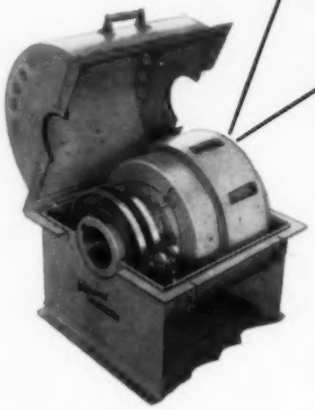
Division of McKIERNAN-TERRY CORPORATION

MANUFACTURING ENGINEERS

Harrison, New Jersey • Plants at Harrison, N. J. and Dover, N. J.



Five Stearns clutches synchronize screw-downs on a large rolling mill. Covers shield clutch from dust, moisture and external damage.



Style E multiple-disc Stearns magnetic clutch used for screw-down duty. Sizes available for all screw-down auxiliary motors.

Low Inertia Stearns Magnetic Clutches Keep Screw-Downs Synchronized on Mile-a-Minute Rolling Mills

QUICK-ACTING, high-torque Stearns magnetic clutches engage and disengage screw-down drives with the lowest possible inertia — a prime necessity on today's rolling mills running at speeds often greater than 6,000 fpm. Because of their high efficiency, more Stearns magnetic clutches are used on steel mill screw-downs than all other makes combined. Here are some of the features that have put Stearns out front, and keep it there:

Precision automatic control — Clutches can be operated through push buttons, electric-eye systems, remote switches or manual controls.

Lightweight, compact — Stearns patented multiple friction-disc clutches provide greater torque than bulky, far heavier single-disc types — offer extremely low inertia value to driven end. This is especially important when little or no drifting is desired after clutch is disengaged.

Few wearing parts — No toggles, pins, yokes, shifters to wear and get out of order. Lining wear increases torque, making frequent adjustment unnecessary.

Simple adjustment — No set screws, cams, wedges, spacers or lock nuts. Simply depress adjustment lock-pin, rotate armature to next notch.

Easy access — Can be removed vertically with motor from mill. Housing covering entire unit is split either horizontally or vertically for easy inspection. Magnetic hub is detachable when used on screw-downs.

For improved quality control it will pay you to replace old-style clutches with new Stearns multiple-disc clutches on existing installations . . . specify Stearns for new mills. Write for complete details.

1121

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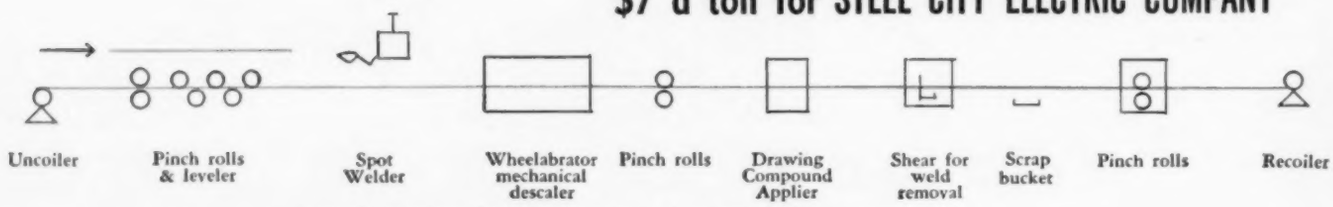
Wheelabrator® Mechanical Descaling saves $7 a ton for STEEL CITY ELECTRIC COMPANY



Schematic Diagram: Strip Cleaning Line, Steel City Electric Company

Only one man is required to operate the mechanical descaling line at Steel City Electric Co.

Strip is Wheelabrated prior to stamping and electrogalvanizing of electrical products.

Cleaning hot rolled 1010 steel strip in a Wheelabrator mechanical descaler for $3 a ton has brought big savings for Steel City Electric Company of Pittsburgh, which was paying a premium of $10 a ton for pickled steel from the mill. The $3 figure includes the operating cost for all equipment in the cleaning line. Cleaning strip up to 48" wide and from .060" to .1875" thick, the Wheelabrator descaler cleans an average of 50 tons of steel in an 8-hour day — a potential saving of $350 in steel costs every 8 hours. Don't let saving like this pass you by — investigate Wheelabrator mechanical descaling today. Find out how it can be tailored to your specific needs.

For more information on Wheelabrator savings for steel processors, write today for Bulletin 128D.

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NEWMAN-CROSBY STEEL HAS RAISED ITS CAPACITY 40%

with this new BLISS mill

Like many another metal producer, Newman-Crosby Steel Company is betting confidently on the continued healthy growth of the American economy! This Rhode Island producer of close-gage cold rolled strip has just raised its capacity a good 40% by installing a new Bliss 4-high reversing mill, as well as new coil-handling and heat-treating facilities.

The 6½" and 16" x 14" mill is used to roll high-carbon and alloy spring steel in gages between 0.125" and 0.010", in widths up to 12" and at speeds to 800 fpm. In actual operation all these design specifications have been exceeded. Bliss also designed and built the coil-handling facilities, including the two tension reels and coil buggies and the pay-off reel. Maximum limit on coil weight is 6,000 pounds.

An unusual roll drive arrangement permits wide flexibility in the choice of roll diameter. Roll speeds are synchronized electrically rather than through gears. Thus, even unmatched roll diameters can be used together successfully.

Building mill equipment to meet special needs . . . or to perform standard operations more efficiently . . . is an important reason why Bliss has become a leader in the field. If you would like more information on Bliss mill innovations, as well as details of many Bliss installations, write us today for a copy of our 60-page Rolling Mill Brochure, Catalog 40-A.

E. W. BLISS COMPANY
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ROLLING MILL DIVISION
SALEM, OHIO

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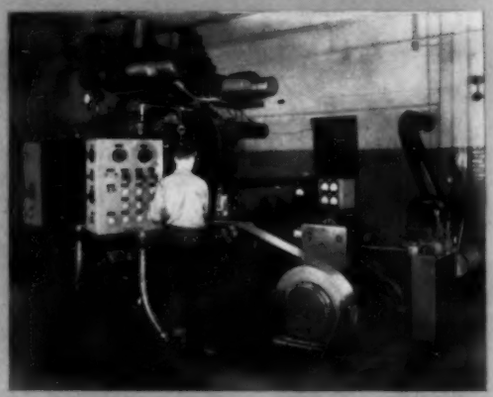
it's a guarantee

The new mill has already outperformed most of the specifications set for it, rolling strip thinner, wider and faster than its original objectives of 0.010-inch gage, 12-inch width and 800 fpm speed.



Another view of the unusual new mill. Elimination of geared roll drive adapts it to use with wide variety of roll diameters to suit different rolling problems.

PLANTS: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California. *In Europe:* E. W. Bliss (England) Ltd., Derby; E. W. Bliss (Paris), France.

Personnel News...

Avery C. Adams, president of Pittsburgh Steel Co. since 1950, has been elected president of Jones & Laughlin Steel Corp. He succeeds **C. L. Austin,** who has been elected vice chairman of the board of directors and chairman of the newly formed Finance Committee of the Corp.

Mr. Adams began his career in the steel industry 37 years ago when he went to work as a laborer in the open hearth department of the Trumbull Steel Co. of Warren, Ohio. When Trumbull merged with Republic Steel Corp. in 1928, Mr. Adams became manager of Tin Plate Sales of Republic. He was elected vice president and a director of General Fireproofing Corp. in 1928 and remained there until 1936. At that time he returned to the basic steel industry and became manager of Sheet Sales for the Carnegie-Illinois Steel Corp. From December 1, 1938 to August 1, 1939, Mr. Adams served as vice president of Inland Steel Corp. He was then chosen to be vice president in charge of sales and a director of the United States Steel Corp. of Del. He occupied that post until late in 1945, from which time until February 14, 1949, he was located in New York as a partner in a steel export and warehouse operation. In February 1949, Mr. Adams became vice president and a director of the Portsmouth Steel Co. On January 1, 1950, he was elected executive vice president and a director of Detroit Steel Corp. On March 1, 1950, he was elected president of Pittsburgh Steel Co. and started the renaissance of that company.

Allison R. Maxwell, Jr., is the new president and chief executive officer of Pittsburgh Steel Co. With 21 years of steel industry experience, Mr. Maxwell moves up from his positions as director and vice president—sales. Since 1952, he has been directing the planning and execution of sales programs relating to Pittsburgh Steel's entry into new sheet and strip markets, in addition to supervising sale of the company's traditional wire and tubular products. Along with Mr. Maxwell's election, Pittsburgh Steel's board of directors also announced selection of **H. B. Collamore** as the new chairman of the board. A director since 1936, Mr. Collamore is the senior member of the board from point of service and has served on the executive committee. **E. M. Barber,** formerly executive vice president and a director, moves up to the newly created position of vice chairman of the board. **Donald C. Duvall,** vice president—industrial relations, has been elected to the board of directors. **Richard McL. Hillman,** formerly treasurer, becomes vice president and treasurer. **Joseph G. Smith,** formerly director of purchases, becomes vice president—purchases and raw materials.

Mr. Maxwell entered Pittsburgh Steel Co. Sales Training Course in 1935, completed it 18 months later and then was assigned to the Metallurgical and Specification Departments of the Monessen and Allenport Works. After that he was promoted to assistant manager of the Industrial Engineering Department serving the two plants. In 1938, he entered the company's Pittsburgh District Sales Office as a wire and wire products salesman. Later, he worked as a special representative handling Pittsburgh Steel's tubular products in the eastern section of the United States. In 1940, Mr. Maxwell was transferred to the Houston district sales office as a sales engineer for oil country and tubular specialties products. Two years later, he entered the U. S. Navy, serving until 1945. Upon returning to Pittsburgh Steel, Mr. Maxwell became manager of control planning. By 1949, he had become assistant general manager of sales. Three years later, he was named a director and vice president—sales.

George A. Kaufman has been promoted to the new position of assistant chief engineer—engineering and planning for Jones & Laughlin Steel Corp. Mr. Kaufman formerly was chief electrical engineer for J&L. **W. H. Wachter** will continue in his present position as assistant chief engineer— plants and construction. Mr. Kaufman has been a J&L employee since 1920 when he joined the firm as an electrical engineering assistant. He was promoted to electrical engineer in 1935, and named chief electrical engineer the same year.

Malcolm A. Jones has been appointed plant engineer of the Kaiser Steel Corp. at Fontana, Calif. Previously, Mr. Jones was associated with the Lackawanna Plant of Bethlehem Steel Co. for 17 years, leaving as assistant chief engineer.

Gordon P. Smith has been appointed general traffic manager of the eastern division of The Colorado Fuel and Iron Corp. He succeeds **Harry H. Marsales,** who retired as traffic manager on August 31 after 41 years with CF&I. Mr. Smith will be in charge of the traffic

AVERY C. ADAMS

ALLISON R. MAXWELL, JR.

GEORGE. A. KAUFMAN

MALCOLM A. JONES

HUGH D. CONNELL

JOHN A. LINDBERG

WILBUR H. PETER, JR.

ALVIN C. DYER

departments of all plants of the company's Wickwire Spencer Steel Division, and of the American Wire Fabrics Corp. and John A. Roebling's Sons Corp., both wholly-owned subsidiaries of CF&I. He will continue to be located at the corporation's offices in Claymont, Del. Mr. Smith has been associated with the Claymont plant since 1947. He has been division traffic manager at Claymont, which is a part of the Wickwire Spencer Steel Division, and also supervisor of transportation at the Claymont plant. Prior to CF&I's acquisition of the plant in 1951, he had held the position of general traffic manager.

Hugh D. Connell has been named manager of the Project Engineering Department, Acme Steel Co. Mr. Connell joined Acme in 1947 as a sales engineer. In 1954, he was appointed a project engineer in the New Products and Improvements Division.

John A. Lindberg has been named manager of Manufacturing Operations for the entire Mackintosh-Hemphill Division of E. W. Bliss Co., Inc. In addition, **Thomas H. Pattison** has been appointed manager of the Pittsburgh plant. Mr. Lindberg, who joined Mackintosh-Hemphill Division in February, was formerly general foreman at the Continental Can Co. and chief metallurgist for Struthers Wells Corp. His experience also includes the position of assistant plant metallurgist in the permanent mold foundry of American Magnesium Corp. Mr. Lindberg replaces **Judson Neff,** who has resigned to devote all his time to his work as an industrial consultant. Mr. Pattison, who has been with Mackintosh-Hemphill for thirty-seven years, succeeds **Charles V. Wilt,** who has retired from the position of plant manager after fifty years with the company. Mr. Wilt will continue to serve as consultant to Mr. Lindberg. Mr. Pattison began with work in the physical and chemical laboratories at the division's 12th St. plant. He was in charge of these laboratories when Mackintosh-Hemphill moved to the Garrison Works on Bingham St. in the early 1920's. Following the move, he was placed in charge of the laboratory at Garrison. In 1929, he was promoted to assistant plant metallurgist, becoming plant metallurgist in 1935. In 1954 he was made general superintendent of the Garrison Works.

Wilbur H. Peter, Jr., has been elected a vice president of Square D Co., and became division manager of the Electric Controller Division in Cleveland, Ohio, effective October 1. Previously works manager of the division, Mr. Peter succeeds **Alvin C. Dyer,** who is retiring as vice president and division manager, but will continue active with Square D as a consultant on the application of the company's electrical controls to steel mills and related heavy industry operations, a field in which he has been active for almost a half-century. Mr. Peter joined Electric Controller and Manufacturing Co. as a sales trainee in 1937 and has been works manager since the firm was merged into Square D last year as a division. He served as a field engineer in Electric Controller's Pittsburgh office for seven years and subsequently held various production and personnel responsibilities in the Cleveland plant. Mr. Dyer joined Electric Controller in 1913 in the Pittsburgh office as a salesman and successively became district manager, general sales manager and, in 1943, vice president of sales. He became a Square D vice president and general manager of the Cleveland operations at the time of the merger last year. Mr. Dyer was earlier associated with Allegheny Steel and Carnegie Steel companies.

D. H. Miller has been promoted to planning and development engineer of Jones & Laughlin Steel Corp. He formerly was resident engineer in J&L's Pittsburgh Works. **R. W. Barnitz** has been named chief electrical engineer. He formerly was chief design engineer at the Pittsburgh Works. **Stephen Vajda** has been appointed special engineer. Mr. Vajda, formerly staff engineer—steelmaking, will direct the engineering research and development activities of the engineering department.

Charles G. Tournay has been promoted to the newly created office of assistant executive vice president of National Steel Corp. Mr. Tournay has had a career of 30 years in the operating and financial departments of the National Steel organization. He began employment with the Weirton Steel Co. in 1926 and advanced to the positions of assistant to the general superintendent, comptroller and then treasurer. In July 1952, he became comptroller and assistant treasurer of National

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- ☐ Dynamometers
- ☐ Accessory Testing

AUTOMOTIVE INDUSTRY
- ☐ Conveyors
- ☐ Machine Tools
- ☐ Presses
- ☐ Dynamometers

CALCINED PRODUCTS
- ☐ Kilns
- ☐ Fans
- ☐ Feeders
- ☐ Conveyors

CHEMICALS
- ☐ Pumps
- ☐ Conveyors
- ☐ Process Machinery
- ☐ Winders

FOOD PROCESSING
- ☐ Mixers
- ☐ Dryers
- ☐ Conveyors
- ☐ Mills

GRAPHIC ARTS
- ☐ Main Presses
- ☐ Press Auxiliaries
- ☐ Winders
- ☐ Slitters

MATERIALS HANDLING
- ☐ Conveyors
- ☐ Cranes
- ☐ Shovels
- ☐ Lift Trucks

MINING
- ☐ Conveyors
- ☐ Hoists
- ☐ Mills

METAL WORKING
- ☐ Rolling Mills
- ☐ Presses
- ☐ Winders
- ☐ Slitters
- ☐ Loop Cars

PULP AND PAPER
- ☐ Paper Machines
- ☐ Auxiliary Helpers
- ☐ Converting Machines
- ☐ Finishing Machines
- ☐ Pulp Processing Machines

RUBBER AND PLASTICS
- ☐ Extruders
- ☐ Plasticizers
- ☐ Calenders
- ☐ Winders

TESTING
- ☐ Engines
- ☐ Pumps
- ☐ Motors
- ☐ Auxiliaries
- ☐ Wind Tunnels

TEXTILES
- ☐ Winders
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- ☐ Dryers
- ☐ Batchers

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- ☐ Boiler Feed Pumps
- ☐ Feeders

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Steel Corp. and in June 1956 was transferred to Weirton Steel Co. as assistant to the president, which was the position held immediately prior to his present promotion.

Dietrich Timmerman has been appointed chief engineer of the Rolling Mill Department of the Birdsboro Steel Foundry and Machine Co. Mr. Timmerman came to Birdsboro from Continental Foundry and Machine Co. Before coming to the United States from Germany in 1951, he worked for many years in the rolling mill engineering departments of several German rolling mill manufacturers and European steel plants. From 1935 to 1947, he served at the Krupps Works in Magdeburg, Germany, starting as chief engineer and later advancing to co-manager of the rolling mill division.

William C. Mullin has been named sales manager for instrument gages of the gage division of the Pratt & Whitney Co., Inc. He assumes the position held by **Albert S. Burgoyne** who is leaving the company on November 1 to become vice president in charge of manufacturing of the E. W. Bliss Co. Mr. Keller also indicated that the sale of conventional gages manufactured at Pratt & Whitney had been combined with the sale of cutting tools under the direction of **Albert F. Miller,** the company's cutting tool sales manager.

William C. Stratton was appointed chief engineer of the Engineering and Construction Department of Dravo Corp. Mr. Stratton comes to Dravo from the firm of consulting engineers, Ebasco Services, Inc., New York City. He had been with Ebasco 11 years and held the position of assistant to the manager of engineering. The company also has announced the appointment of **A. A. Nilsen** as manager, ore agglomeration in the Engineering and Construction Department. Mr. Nilsen was associated in various capacities with the American Ore Reclamation Co., and most recently was assistant manager of the American Ore Reclamation Section of Koppers Co., Inc.

M. H. Kessler has been advanced to assistant vice president of Quality Control at Weirton Steel Co. Other promotions announced were: **G. F. Buckle** to manager—service and inspection; **S. J. Dougherty** to chief metallurgist; and **C. J. Vincent** to assistant manager—service and inspection. Mr. Kessler began his employment with Weirton Steel Co. in 1933, and held the position of chief metallurgist prior to his current appointment. Mr. Buckle joined Weirton in 1936 and was head of service and inspection—tin mill products immediately prior to assuming his new duties. Mr. Dougherty began working for Weirton in 1929 and held the position of assistant chief metallurgist prior to his current appointment. Mr. Vincent started to work for Weirton in 1940 and was head of service and inspection—strip mill products at the time of his new appointment.

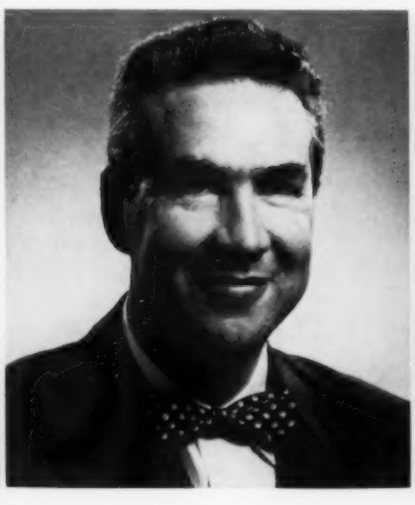
Jack E. Saxer has been appointed assistant chief industrial engineer, Methods & Standards, of Jones & Laughlin Steel Corp. Mr. Saxer joined J&L in 1946 as an industrial engineer in the general office. He was supervisor, Methods and Standards Division, before his new appointment. From 1950 to 1952 he served as assistant works industrial engineer at J&L's Pittsburgh Works Division. Before coming to J&L, Mr. Saxer was an industrial engineer with Armco Steel Corp., which he joined in 1939.

William R. McCalister has been appointed general superintendent of the Ellwood Works, of National Tube division, United States Steel Corp. He succeeds **H. W. Hudson** who is retiring after 41 years of service at the Ellwood City plant. Mr. McCalister began his career with National Tube as a laborer at Ellwood Works in 1933. Soon afterward he was enrolled in the apprentice engineering course. He served in various capacities in the engineering department and in 1941 became chief plant industrial engineer. In 1951 he was made superintendent of the hot mills at Ellwood Works where he served until June 1953 when he was appointed assistant general superintendent of National Tube's Gary Works, Gary, Ind., a position he held at the time of his present appointment.

Elmore H. Broadhurst, former works manager of the Titusville, Pa., plant of the Universal-Cyclops Steel Corp., has been named general manager—Cyclops Division. In his new capacity, Mr. Broadhurst will assume full responsibility for all operating, administra-

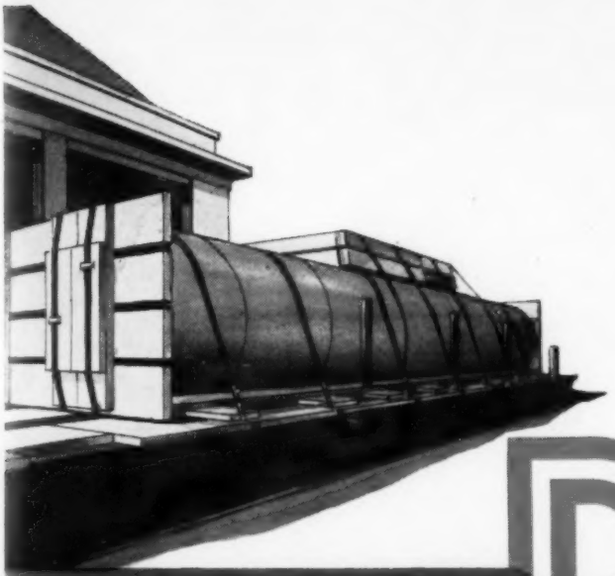
DIETRICH TIMMERMAN

WILLIAM C. MULLIN



WILLIAM C. STRATTON

A. A. NILSEN



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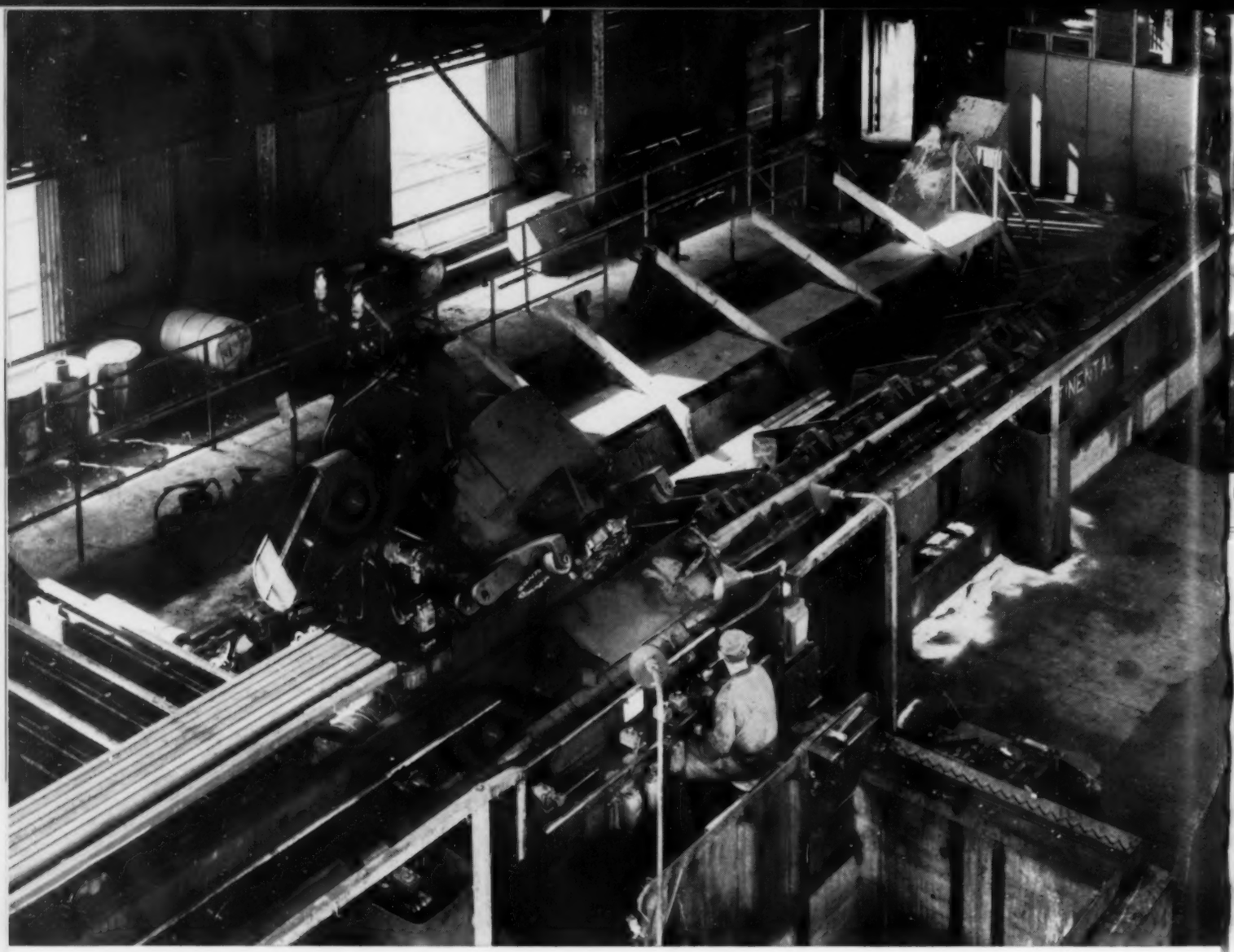

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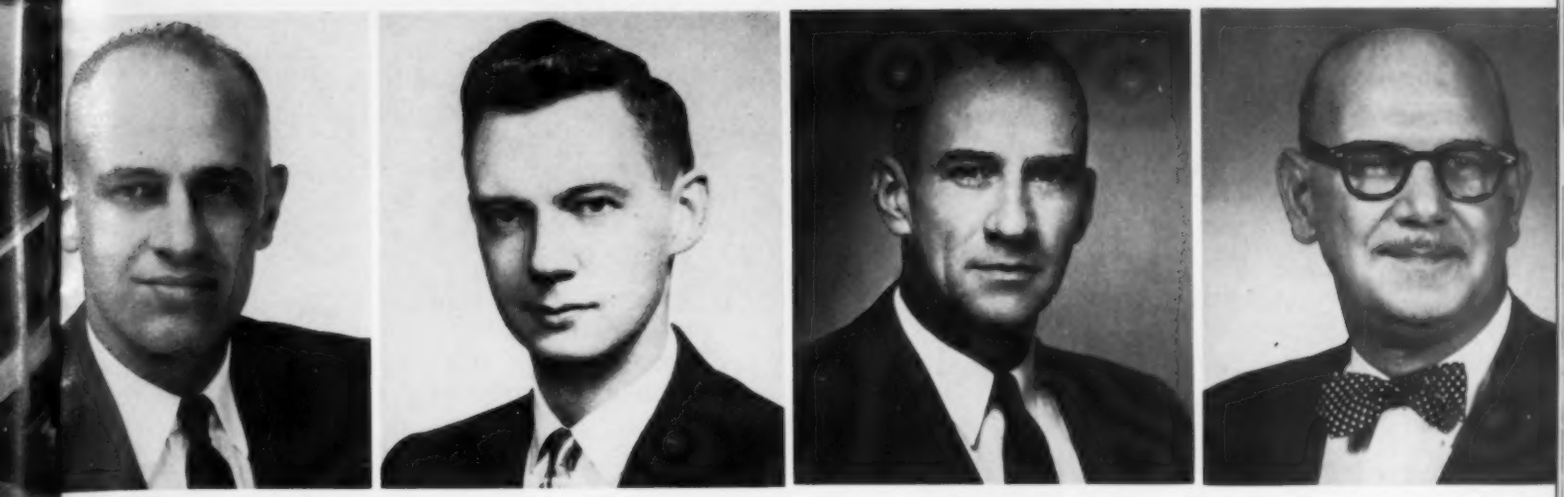


FREDERICK A. FIELDER E. A. IRION E. N. HOWER M. C. BELZ

tive, and technical activities of the division, reporting directly to the president. Mr. Broadhurst has been associated with Universal-Cyclops since 1936 in various operating and management positions.

Frederick A. Fielder was named general sales manager of Loewy-Hydropress Division of Baldwin-Lima-Hamilton Corp. Mr. Fielder has twenty years of experience in the hot and cold working of ferrous and non-ferrous metals, machinery, building and ordnance. He has, for several years, been Loewy-Hydropress project and procurement coordinator for the United States Heavy Press Program, and was recently appointed assistant to the general manager.

E. A. Irion has been named a district application engineer in its Pittsburgh office by the Clark Controller Co. He previously was a district application engineer in Clark's Syracuse office, and has served in the company's Buffalo and home offices.

E. N. Hower was named manager, Engineering and Construction Department Sales of Dravo Corp. Mr. Hower formerly was manager of the Machinery Division's Industrial Department and has been a member of the Dravo organization since 1947.

M. C. Belz, formerly of Johns-Manville Corp. and Omholt Brothers, was named manager of the Industrial Mastic Division of Chemsteel Construction Co., Inc. Mr. Belz will handle acid resisting mastic along with the company's regular services from the Philadelphia office.

Paul W. Pheneger was appointed administrative vice president of the Pollak Steel Co. Mr. Pheneger was formerly associated with Superior Steel Corp. as general superintendent.

W. W. Gilmore has been elected a vice president of Minneapolis-Honeywell Regulator Co. He is president of the company's Micro Switch division in Freeport, Ill. and will continue to hold that post.

R. D. "Bill" Jones was named general sales manager of the Automatic Transportation Co. Mr. Jones succeeds **George A. Hinckley** who becomes manager of Automatic's New York sales and service branch which he formerly served as sales manager. **Philip E. Whiting,** former branch manager, is continuing as sales advisor until his retirement.

Earle C. Smith has been appointed director of research of Republic Steel Corp. He will also continue as chief metallurgist of the company. As a result of this appointment, Mr. Smith will have direct supervision over Republic's new research laboratory which will soon be under construction in Independence, Ohio.

J. A. Farnsworth has joined the Mead-Morrison Division of McKiernan-Terry Corp. as a sales engineer.

J. A. FARNSWORTH

Mr. Farnsworth, a graduate of Carnegie Tech, with a degree in civil engineering, has been assigned to the Harrison, N. J., office, from which he will cover the territory around and to the east of Pittsburgh.

Eugene R. Johnson has been appointed an application engineer in the steel mill section of Allis-Chalmers control department. Mr. Johnson was an experimental engineer in the electrical department of the Bethlehem Steel Co. before joining Allis-Chalmers.

Alexander H. d'Arcambal will retire as president and general manager of the Pratt & Whitney Co., Inc., on November 1. Mr. d'Arcambal will remain active in

company affairs in a consulting capacity and as honorary chairman of its board of directors. **Edward P. Gillane,** executive vice president and a director of the company, will succeed Mr. d'Arcambal as president.

John P. Walsh has been appointed sales engineer of Pittsburgh Engineering Co. He was formerly associated with Morgan Engineering Co., Youngstown Foundry & Machine Co., and Wean Engineering Co.

JOHN P. WALSH

Wm. C. McCosh has been appointed manager of railroad and industrial brush sales for National Carbon Co., Division of Union Carbide and Carbon Corp. He will make his headquarters at National Carbon's home offices in New York City. Three other appointments were made at the same time. **J. W. Scales** was named manager of the mid-eastern division of the carbon products sales department. He will make his headquarters at National Carbon's Pittsburgh offices. **R. L. Westlake** was appointed manager of the central division of the carbon products sales department, and will make his headquarters at the Chicago offices. **A. W. Wolff** has been named manager of carbon specialty sales. He will make his headquarters at National Carbon's Cleveland offices.

Robert P. Sayers was appointed manager of Link-Belt Co.'s Duluth, Minn., district office. Mr. Sayers joined Link-Belt in 1931, and since 1945, he has been a district sales engineer in the company's Chicago sales office working closely with the steel mills and other heavy industries in the area on their materials handling and power transmission problems. Before this, he served in the shop, engineering, and sales departments of Link-Belt's Pershing Road plant in Chicago. **J. E. Morrison,** former Duluth district manager, will concentrate on engineering and product development to further broaden Link-Belt service in the iron range territory.

Robert W. Snowdon has been appointed special assistant to the vice president in charge of purchases and traffic for Heppenstall Co. Mr. Snowdon started with the company in 1936. He was appointed manager of the plant at New Brighton, Pa., in 1950, and assistant to the general manager of operations in 1954. He served as assistant manager of ring sales in 1956.

Donald E. Cummings has been promoted to manager, Steel Mill Sales Division, Air Products, Inc. He replaces **Arthur E. Steele** who is on special assignment with the company. Mr. Cummings was formerly a sales engineer in that Division. Two additional sales engineers were appointed to the Steel Mill Sales Division. They are **Robert B. Schultz,** formerly a sales engineer with the Elliott Co. and **John K. Stewart,** formerly assistant to the President, Industrial Nucleonics Corp.

Paul R. Brucker has been named division metallurgist in charge of flat rolled products and **Michael Zetz** has been appointed division metallurgist in charge of melting and bar products, of Crucible Steel Co. of America.

R. H. Cline, formerly manager of Allis-Chalmers Manufacturing Co.'s Charlotte district, has been appointed manager of the Pittsburgh district of the company's Industries Group. He succeeds **J. K. Keogh,** who continues as a special representative reporting to **V. L. Spinney,** manager of the Central Region.

Obituaries

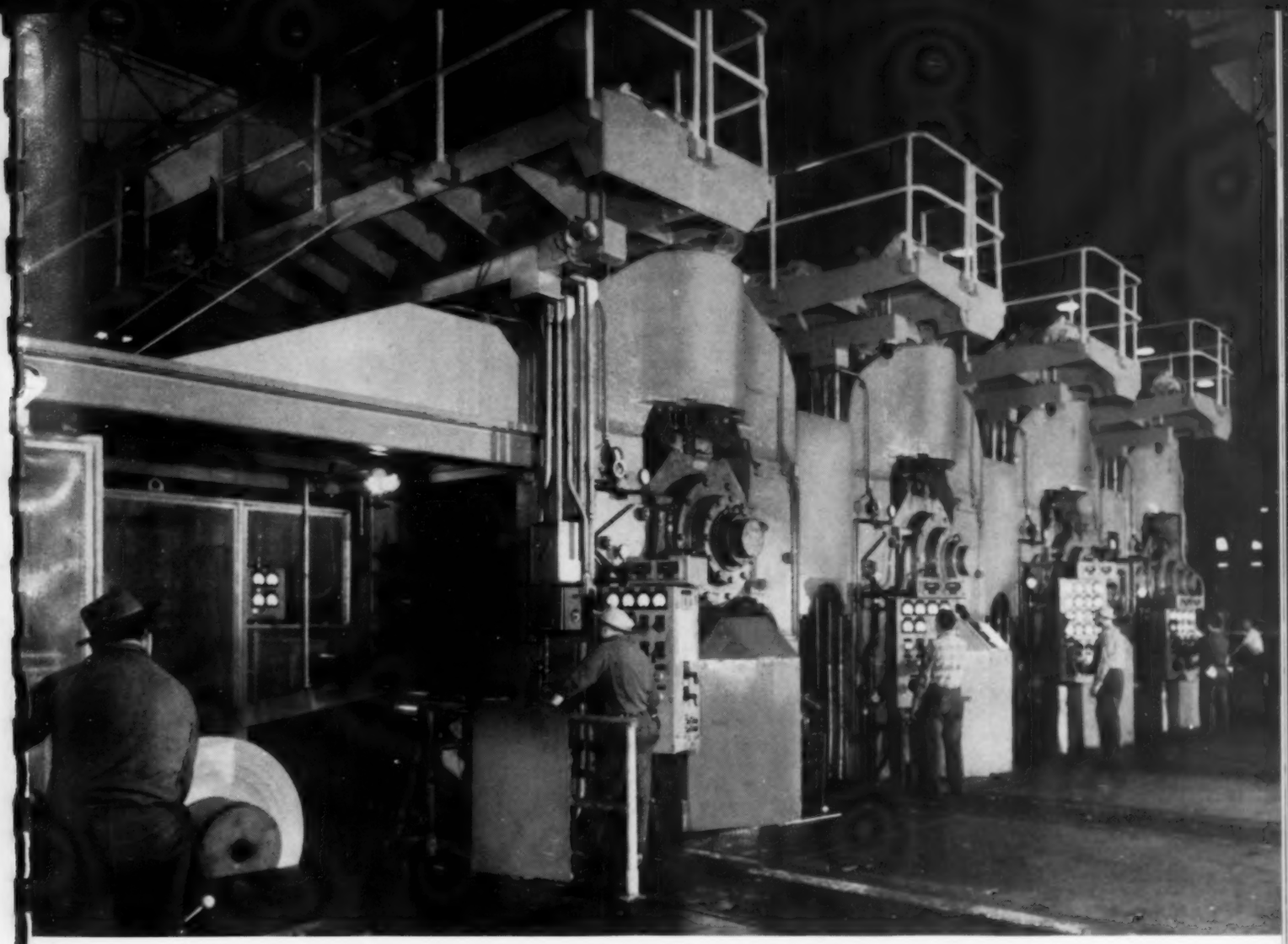
Anthony W. Taylor, director of purchases for Crucible Steel Co. of America, died September 15. He was 56.

Arthur J. Bradshaw, head of the firm of Bradshaw & Sons, Consulting Electrical Engineers, Youngstown, Ohio, died August 28, 1956. He was 57. He was formerly associated with the Osborn Engineering Co., and the Arthur J. McKee Co., and formerly vice president of the Middough Associates in Youngstown. Mr. Bradshaw was a member of the AISE.

E. E. Offerdahl, electrical superintendent of the Copperweld Steel Co., Warren, Ohio, died August 30.

H. A. Leermakers, formerly building engineer, Engineering & Construction Department, Bethlehem Steel Co., Bethlehem, Pa., died July 13, 1956.

Joseph M. Schaeffer, 71, president of the Waterbury Farrel Foundry & Machine Co., died September 7. Mr. Schaeffer had a world-wide reputation as an authority in the field of cold-process bolt, nut, and screw machinery. He was associated with Waterbury-Farrel for 51 years.



This 66" four-stand tandem cold strip mill at Pittsburgh Steel operates at speeds up to 3190 fpm maximum, has 17,700-hp total drive motor capacity.

Higher speed . . . more on-gauge strip

with Westinghouse Magamp* regulators on coordinated mill drive systems

In March, 1954, the first tandem cold reduction strip mill controlled entirely by Westinghouse Magamp magnetic amplifier regulators was installed at the Pittsburgh Steel Company, Allenport, Pennsylvania. This control's performance since then has resulted in higher permissible operating speeds and more on-gauge strip. Practically no adjustment or maintenance has been required on the mill stand and reel regulating equipment.

Two other four-stand tandem mills with individual generator power supply and all Magamp control are operating successfully, and equipment for four additional mills is being manufactured or installed.

*Trade-Mark

See how Westinghouse coordinated drive systems are Magamp controlled for greater productivity

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

Precise Magamp power control yields . . .

More on-gauge strip at 6000 fpm and beyond

More on-gauge strip during acceleration, deceleration and rated speed rolling are yours with Westinghouse Magamp regulators . . . even with the trend toward greater power application. Results are fewer waste ends, increased productivity.

A Magamp regulator system delivers optimum over-all mill performance because it properly regulates and improves the response characteristics of mill and reel motors and power supply generators.

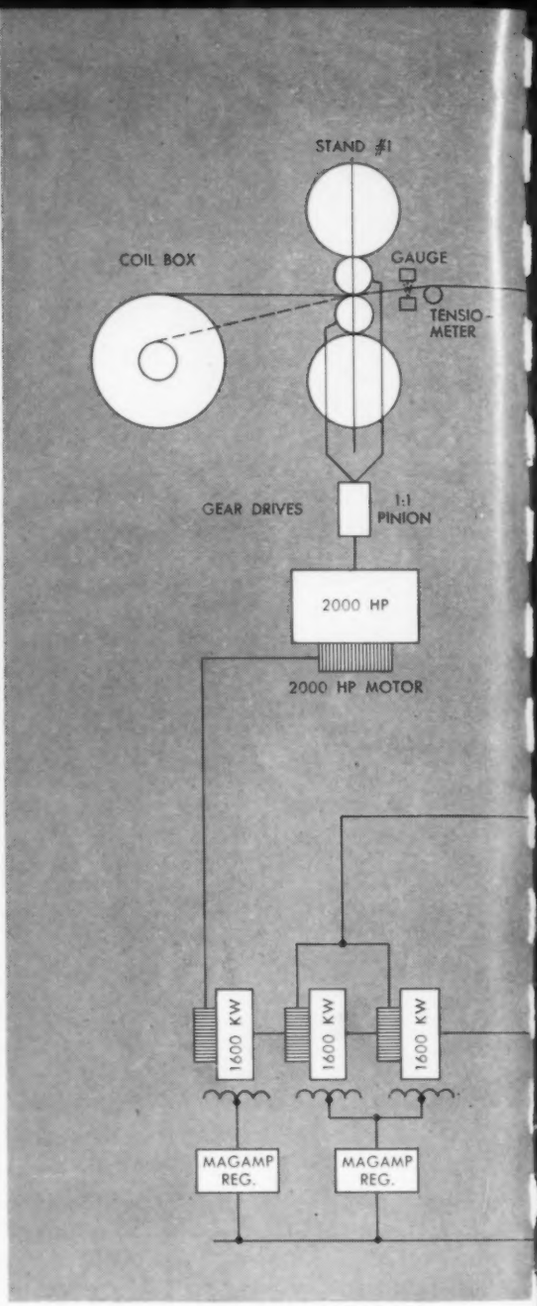
Magamp's high amplification and extremely short response time assure accurate generator voltage control. Operation from 400 cycles gives fast response and inherent stability without complex or critically adjusted damping circuits. Here's how the system works:

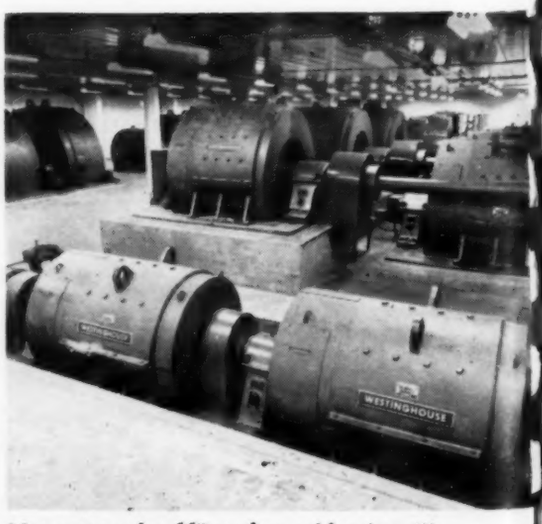
DRIVE ARRANGEMENT—Working rolls in mill stands one and two are driven together through pinion stands. Upper and lower rolls in stands three, four and five are driven separately through offsetting speed-up gears, the 6000-hp #5 drive consisting of two 3000-hp, double-armature motors. Winding reel motor is 1500-hp, triple armature. Each stand and reel drive is supplied from separate generators, on two motor-generator sets with duplicate 12,000-hp synchronous driving motors.

MAGAMP REGULATOR CONTROL—Generator(s) for each stand and reel power supply is controlled by a Magamp voltage regulator, operating on 400-cycle, three-phase supply from an alternator set.

AUTOMATIC GAUGE CONTROL—Strip thickness gauge at stand one controls stand one screwdown to minimize variations in starting hot strip and to feed uniform strip to rest of mill. Gauge at stand five controls stand five motor speed, and tension between stands four and five to maintain constant gauge of finished strip.

TENSIOMETERS—Units between stands indicate total tension and difference in tension between two edges of the strip.

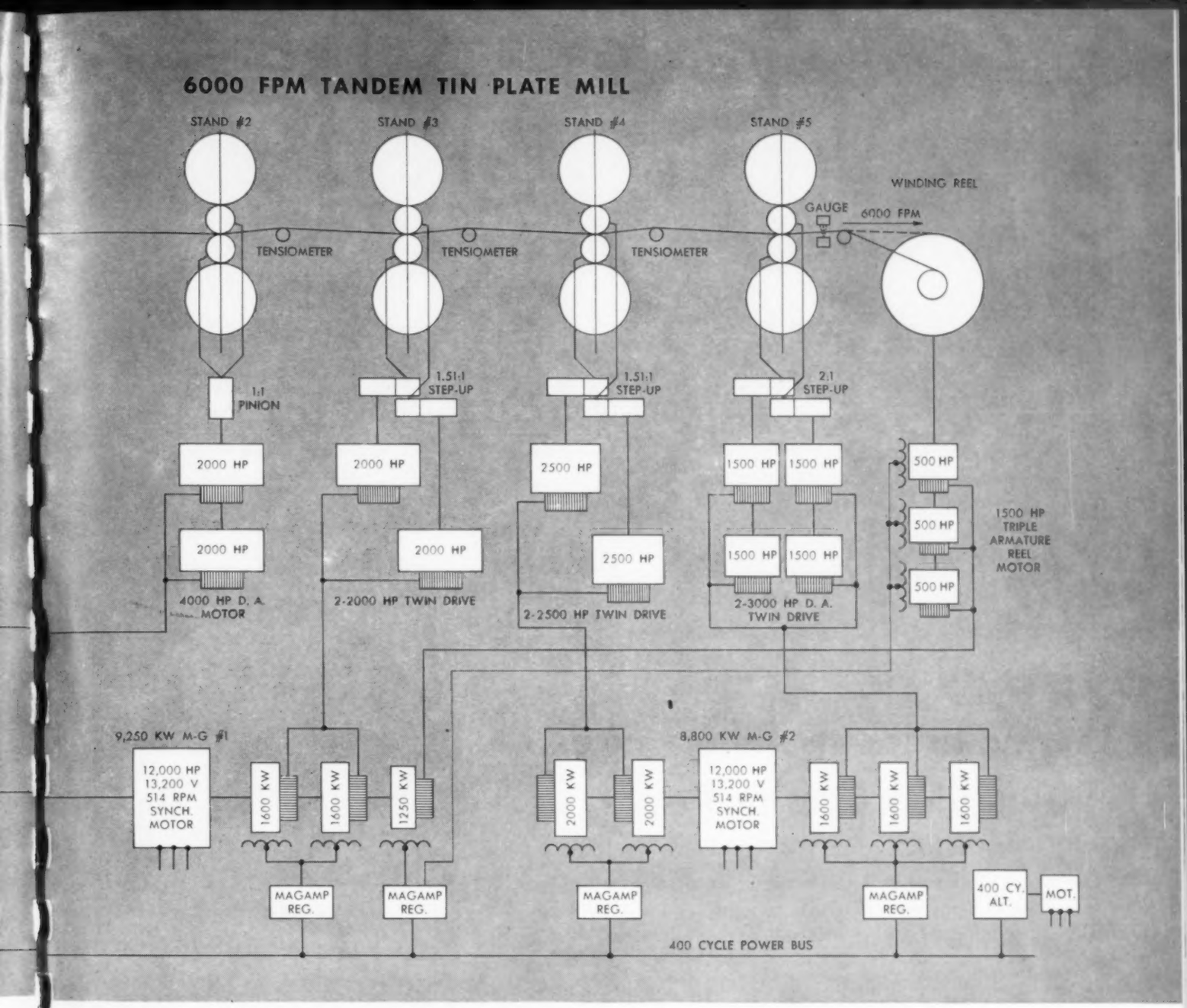




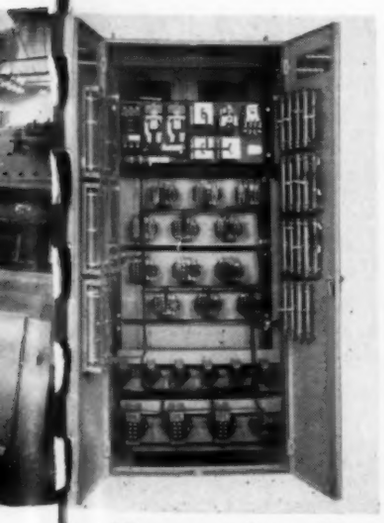
Motor room for 66" tandem cold strip mill.

WATCH WESTINGHOUSE!

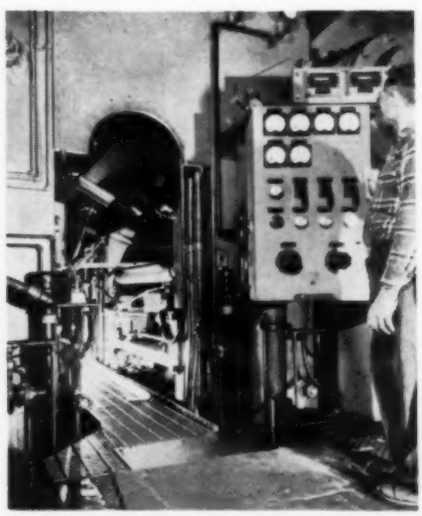
*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***



A 48"-wide five-stand mill like this is now under construction for the Wheeling Steel Corporation. It will have 22,500-hp total drive capacity to produce tin plate and heavier strip at speeds up to 6050 fpm.



Magamp regulator cabinet.



Tensiometer between mill stands.

Progressive users of Magamp regulator control on tandem cold strip mills

PLANT	YEAR	STANDS AND WIDTH	DELIVERY FPM	TOTAL HP
Pittsburgh Steel Co. Allenport, Pa.	1954	4—66"	1595/3190	17,700
Alan-Wood Steel Co. Conshohocken, Pa.	1954	4—32"	1100/2293	6150
Empire Steel Corp. Mansfield, Ohio	1955	4—52"	747/1868	8100
Usinor Montataire, France	1956	4—66"	1375/3630	19,450
Nonferrous—Ohio	1956	4—32"	850/2075	4400
Steel Mill—Ohio	1957	3—80"	747/1670	13,000
Wheeling Steel Corp. Yorkville, Ohio	1957	5—48"	2750/6050	22,500

Westinghouse Exclusive!

Thermalastic® insulation excels in punishing steel mill duty

Twenty percent greater dielectric strength, ten times greater voltage endurance, 30 times greater tensile strength . . . that's Thermalastic, an amazing insulation available exclusively from Westinghouse.

Thermalastic shrugs off moisture, high voltage and dirt . . . helps Westinghouse motors and motor-generator sets better withstand severe steel mill operating conditions.

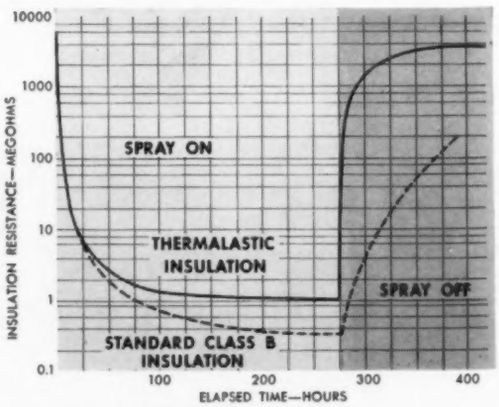
A chemically stable, highly moisture-resistant impregnating resin is used in Thermalastic. This, plus a high degree of fill achieved in the impregnating process, gives Thermalastic extraordinary properties that extend its life in hard service.

Remember, too, Westinghouse switchgear, control centers, ventilation equipment, and gearing are excellent working partners for your Westinghouse coordinated mill drive systems.

From planning to design, installation and start-up . . . Westinghouse is at your service. An experienced Westinghouse team will accept unit responsibility, and work with your engineering staff and consulting engineers in setting up your tandem mill drive.

Contact your Westinghouse sales office for further details. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. MP-3046

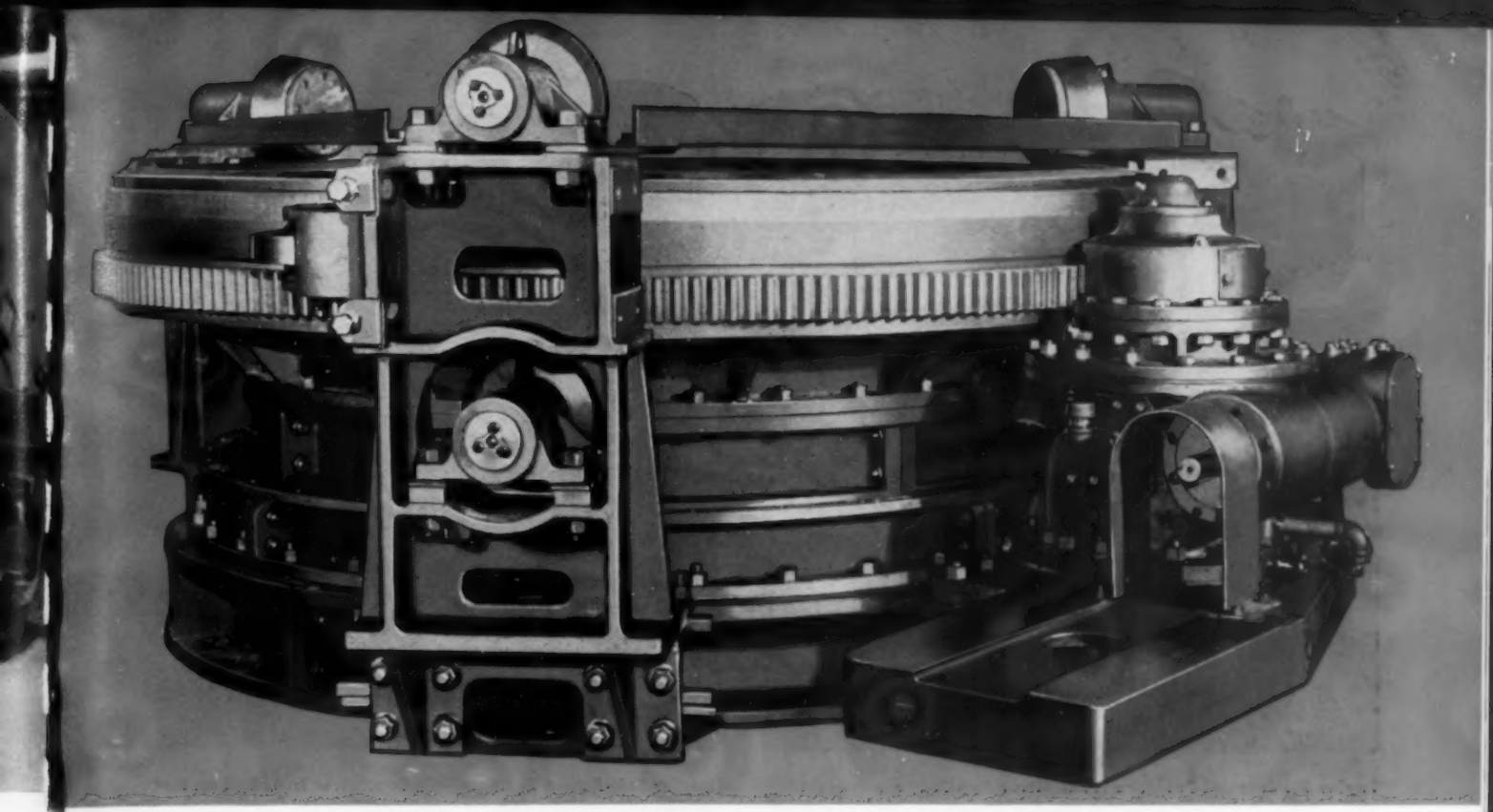
Thermalastic-insulated Westinghouse motor-generator sets (top photo) for 66" four-stand tandem cold strip mill.



Results of typical laboratory spray test demonstrate superior moisture resistance of Thermalastic compared to regular insulation.

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***



New model McKee Heavy-Duty Distributor* ready for installation of revolving hopper.

NOW... a new McKee Distributor with Heavy-Duty features

for smaller Blast Furnaces

FOR fifty years the McKee Distributor has been virtually standard equipment throughout the industry. With the advent of modern, large-hearth-diameter furnaces McKee designed the large Heavy-Duty Distributor which has proved so successful on the newer furnaces. This year McKee produced a new intermediate model incorporating the best features of the large heavy-duty model in a distributor recommended for "high-pressure operation" on smaller, existing furnaces. Five of the new units are already in operation and three others are now being installed. Both Heavy-Duty models are also available with a special seal for high-speed operation without appreciable increase in horsepower requirements.

Heavy-Duty design assures you lower maintenance... improved, uninterrupted performance

TRIPLE, GREASE-LABYRINTH GAS SEAL with improved, resilient packing in contact with a smooth, hard-chrome-plated surface. Experience with this same seal on the large McKee Heavy-Duty Distributor indicates that not more than one packing change is required during the campaign of a blast furnace.

RUGGED, MANGANESE-STEEL BELL SEAT is easily accessible by removing the revolving hopper only, without disturbing ring gear, rollers or seal.

THREE ROLLER STANDS support top, bottom and side rollers in a compact design which provides maximum accessibility for inspection and maintenance.

WEAR IS REDUCED by distributing loads over wider ring gear and pinion faces, larger roller and roller track insert surfaces.

ROLLER BEARINGS of liberal size in top, bottom and side rollers, bell rod support and drive unit are sealed against dirt.

AMPLE SAFETY MARGIN is provided by heavy construction, with every part designed to withstand far more than maximum expected load.

*PAT. PEND.

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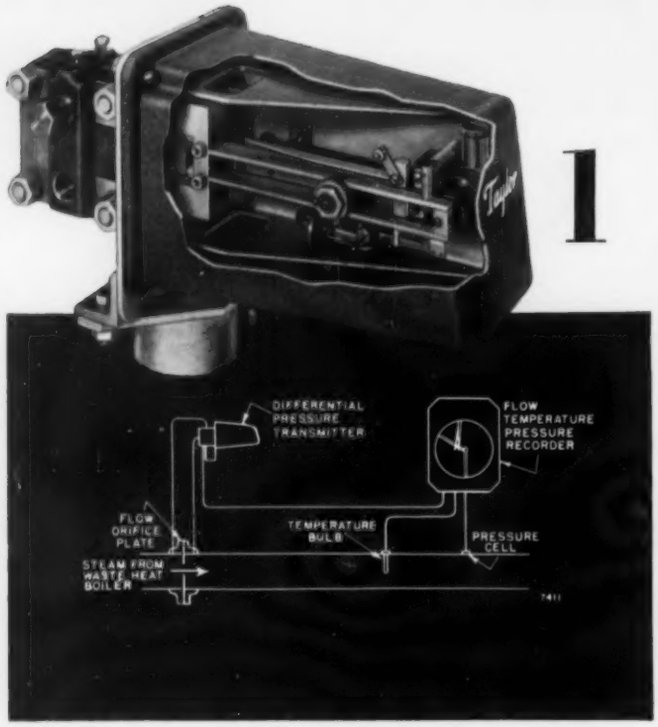
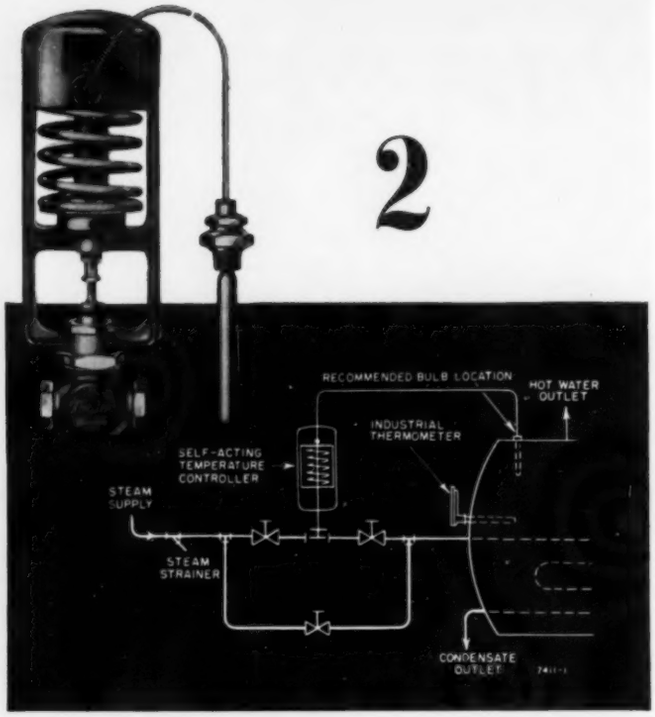
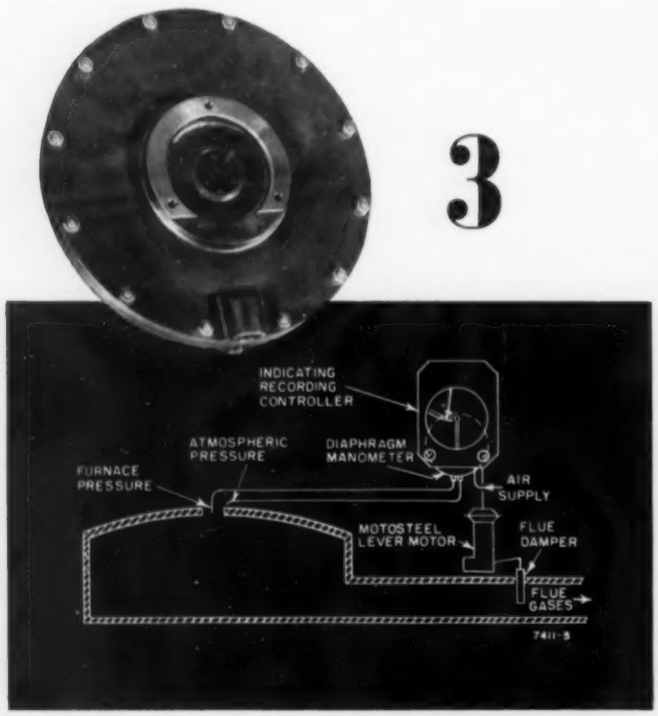
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto



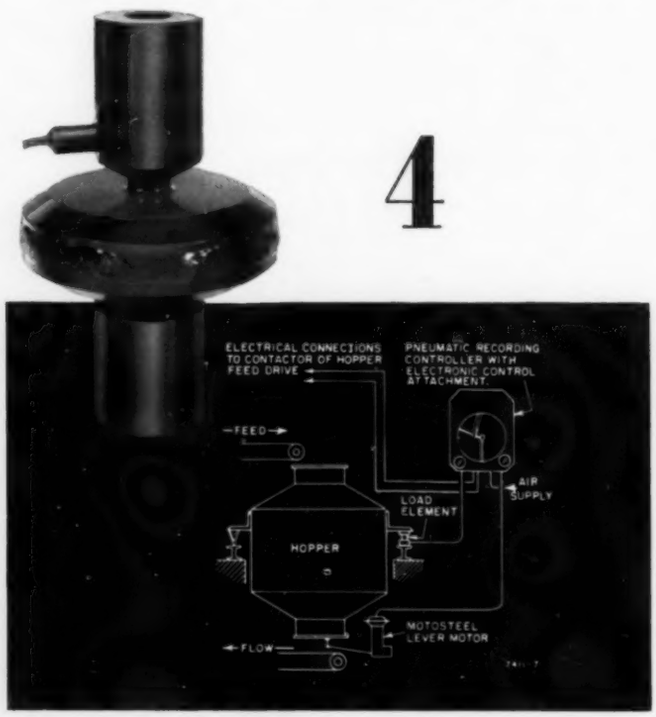
Taylor Differential Pressure Transmitter Applied to a Process Flow Line. A light-weight transmitter that's rugged, dependable and accurate. Measures flow, liquid level or specific gravity. Range can be set with micrometer accuracy—accurate within 1% of range. Ten-to-one adjustability in each of 2 ranges: 20″ to 200″ and 80″ to 800″ water.



Taylor Self-Acting Temperature Controller Installed on Hot Water Tank. Here's a sturdy instrument for use where advantages of air-operated controllers aren't required. Needs minimum maintenance and attention. Numerous standard temperature ranges within 10° and 340°F.; semi-standard within 165° and 610°F. Choice of bulb material and type of connection.



Taylor Diaphragm Manometer for Furnace Pressure or Draft Control. Particularly suited for accurate low pressure measurement of air or gas, static or differential, with operating ranges as low as minus 0.5 to plus 0.5 inches or up to 0 to 4 inches of water. Designed for close fitting on back of Taylor indicating, recording and controlling instruments or transmitters.

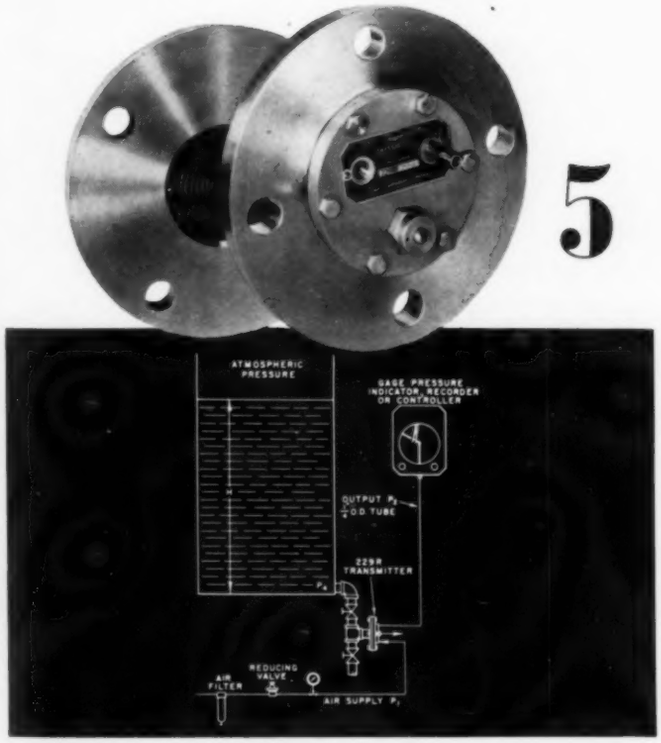


Precise Weight Measurement and Control of Solids in Hopper. Taylor Volumetric Load Measuring Elements provide a simple and economical method for directly measuring load or force, such as the weight of solids or corrosive liquids in a tank, tension on a conveyor belt, etc. Units indicate or record up to 200 ft. from point of measurement. Accuracy averages 99%, unaffected by friction or hysteresis in loading system.

TAYLOR INSTRUMENTS

5 WAYS

TAYLOR CAN WORK HARD FOR YOU!



Taylor 229R Pressure Transmitter for Liquid Head in Tank. A 1-to-1 force-balance pressure transmitter specifically designed for liquid-level measurement, the Taylor 229R Transmitter converts process pressure to an equal air pressure for relay to indicating, controlling or recording instrument—as much as 1000 feet from transmitter! Ideal for viscous or corrosive liquids and slurries. No need to bubble air through process liquid.

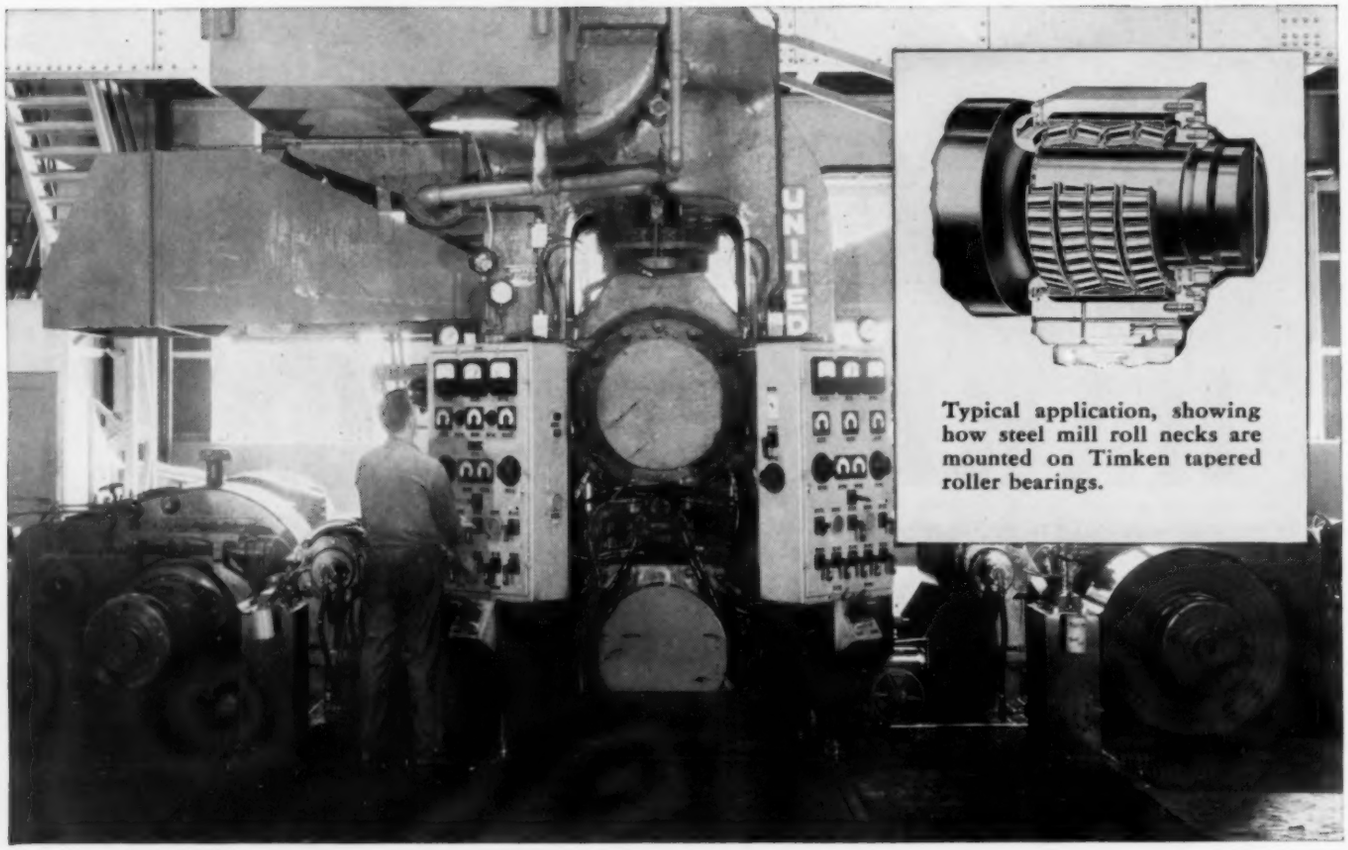
"RUGGED instruments built to withstand hard service"—this tells part of the story of the five Taylor Systems shown here. They are representative of the many practical applications of Taylor instruments in metals and by-products processing. The rest of the story comes in words like "accurate, dependable, automatic" . . . words like "operating efficiency, consistent product quality, lower production costs."

These words fit into the story of your product as today's advanced metals production and processing methods increase their demands for automatic control. Taylor Instruments like these help solve processing problems, help keep costs low, help keep quality high.

For specific suggestions on how Taylor can work hard in your plant, call your Taylor Field Engineer or write for **Bulletin 98261.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

MEAN ACCURACY FIRST

Scrap loss minimized with reversing cold mill back-up rolls on TIMKEN® bearings



Typical application, showing how steel mill roll necks are mounted on Timken tapered roller bearings.

THE back-up rolls on this United Engineering 6″ & 34″ x 30″ 4-high reversing cold mill at Allegheny Ludlum's Leechburg plant are mounted on Timken® tapered roller bearings. Timken bearings give low torsional resistance, regardless of operating speed or load. This eliminates the need for altering or relieving screw-down pressure — maintains gauge which minimizes scrap loss at each end of the coil. Less hydraulic accumulator pressure is needed with rolls driving easier on Timken bearings, which reduces bearing wear, cuts maintenance cost.

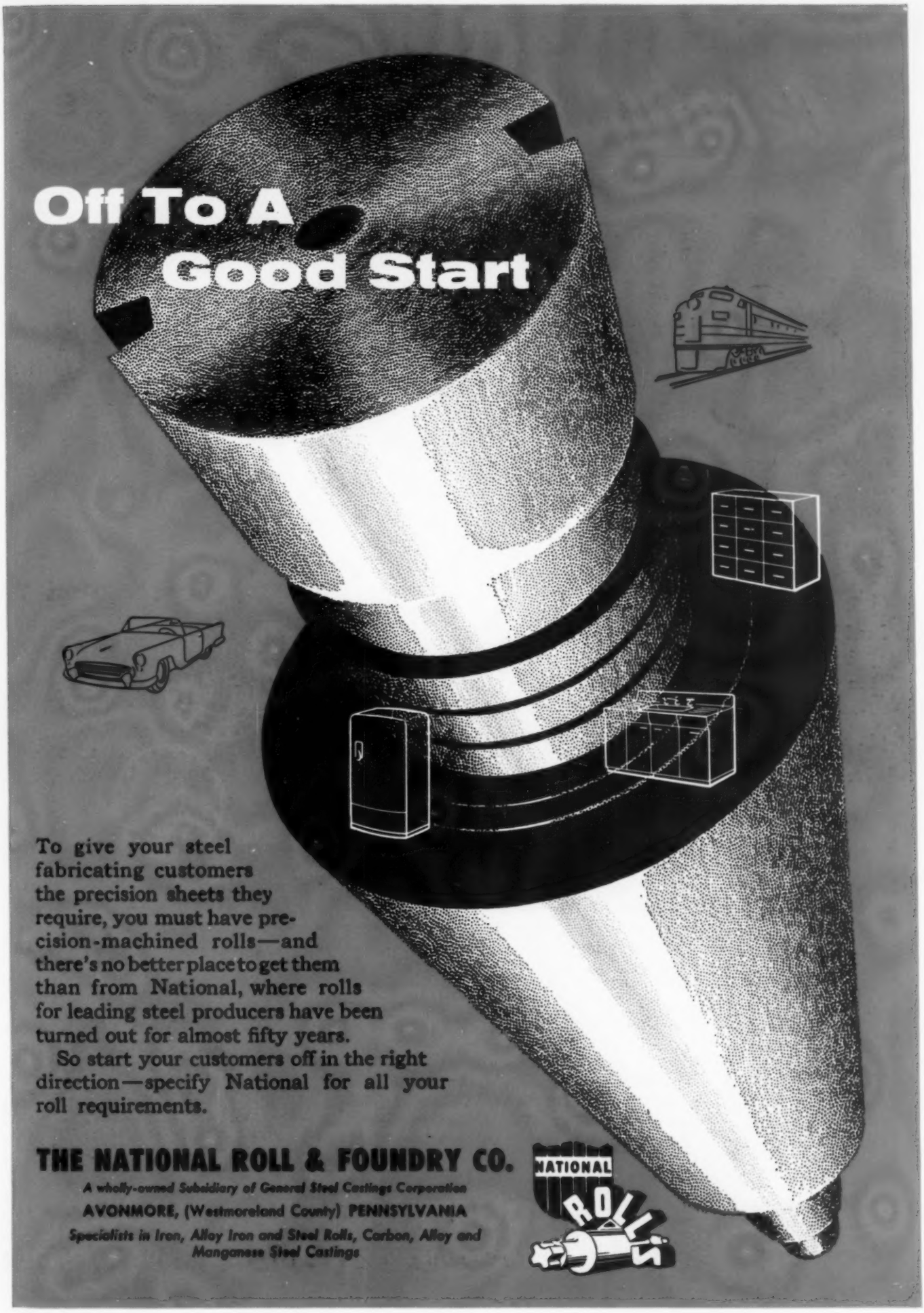
The balanced proportion design of Timken bearings provides maximum capacity in a given space. Timken tapered roller bearings give you greater mill rigidity, permit large diameter roll necks. They take both radial and thrust loads in any combination, require *no extra thrust devices*—which means more compact chuck mountings, simplified mill design. And by holding mill rolls rigid, Timken bearings help insure "on-gauge" operation, cutting scrap loss and reducing still further the cost per ton of steel rolled.

With Timken bearings, roll and chuck are held concentric, making closures more effective. There's less leakage of lubricant. And with economically grease-lubricated Timken bearings, lubrication requires no tubes, pipes or reservoirs. When you build or buy machinery, look for the trademark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.



To give your steel fabricating customers the precision sheets they require, you must have precision-machined rolls—and there's no better place to get them than from National, where rolls for leading steel producers have been turned out for almost fifty years.

So start your customers off in the right direction—specify National for all your roll requirements.

THE NATIONAL ROLL & FOUNDRY CO.

A wholly-owned Subsidiary of General Steel Castings Corporation

AVONMORE, (Westmoreland County) PENNSYLVANIA

Specialists in Iron, Alloy Iron and Steel Rolls, Carbon, Alloy and Manganese Steel Castings

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Careful Mister!

Be very careful! The gear in your hand must be delivered ASSEMBLY READY. Every tolerance must be held well within the customer specification. Remember, IG's most modern gear cutting machinery can do only the mechanical part of the job. You, personally, are the element to make IG cut gears better; more dependable.

Depend on IG to deliver any type or size cut gear Assembly Ready—on time—priced right. Send for new, complete literature.

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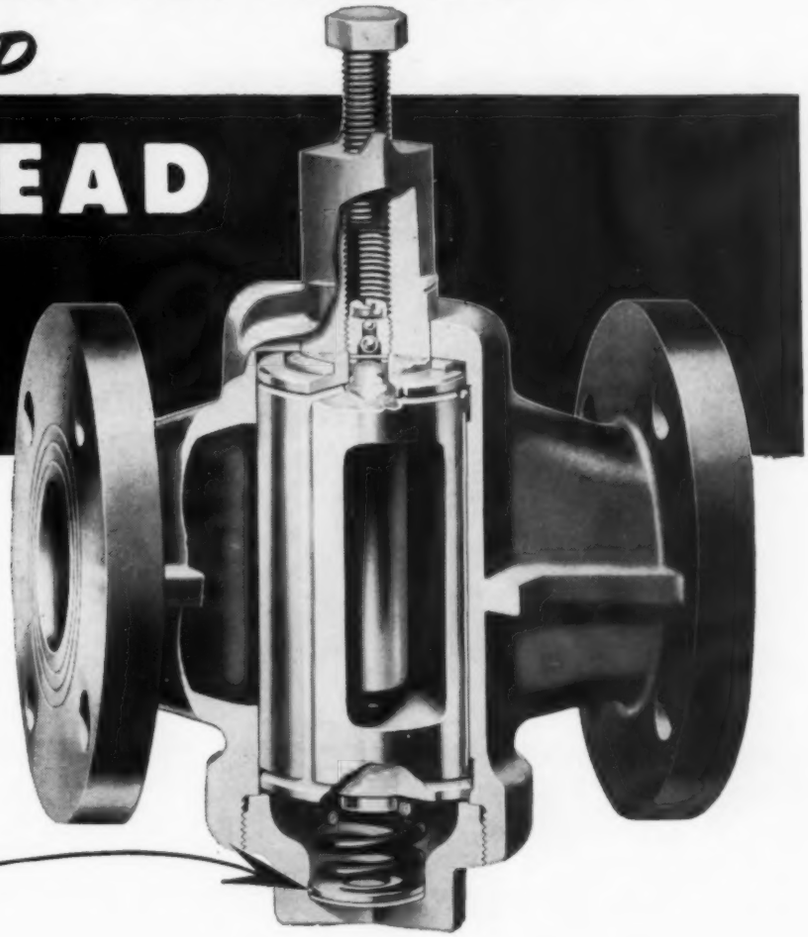
No. 4* of 12 REASONS WHY
YOU SHOULD BUY AND USE
LOW-PRICED
HOMESTEAD
Lubricated
PLUG VALVES



* SPRING TORSIONAL STRESS RELIEVED BY TEFLON WASHER

Low friction Teflon washer permits spring to turn with plug. This means that less maintenance and longer life are assured, because the spring is subjected to compression only.

This is only **one reason why you should buy and use low-priced** HOMESTEAD LUBRICATED PLUG VALVES.

HERE ARE ALL TWELVE

1. Extra long valve life assured by very close tolerance between sealing surfaces.
2. Straight line fluid flow—streamlined ports — minimum resistance to flow — minimum pressure drop.
3. Triple head seal—two lubricant rings and reinforced Teflon stem seal prevent leakage.
4. Easy turning — plug floated on Teflon washer and reinforced Teflon ring.
5. Leak-proof double ball and lubricant sealed check valve. No springs. No maintenance.
6. Full-threaded screw prevents dirt being forced into lubricant system.
7. Quarter-turn fully opens or closes.
8. Reinforced Teflon stem seal — no cold flow—continuous, positive seal.
9. Seating surfaces protected in both open and closed positions.
10. High pressure lubricant system provides full lubricant seal around ports.
11. Self-freeing plug prevents sticking.
12. Two lubricants handle most services.

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HOMESTEAD
VALVE MANUFACTURING COMPANY
"Serving Since 1892"

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Without obligation, send Reference Book 39—Section 5 on HOMESTEAD LUBRICATED PLUG VALVES.

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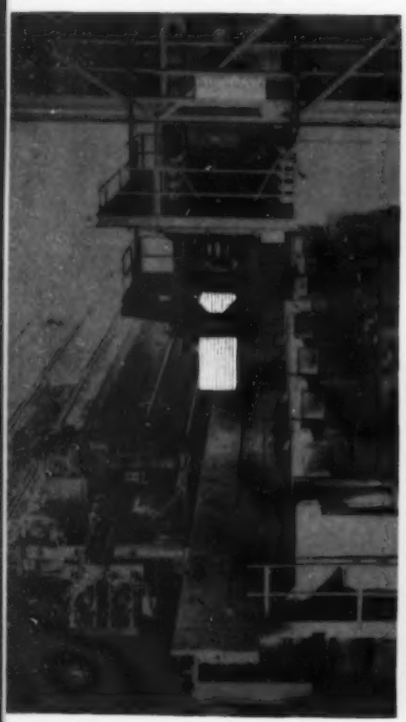

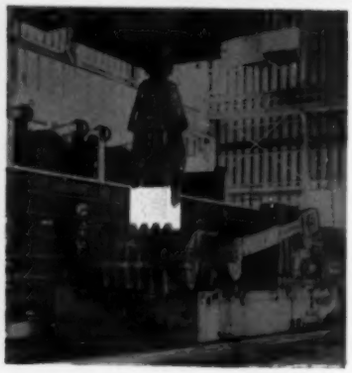

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TO ROLL

New batteries of Surface® one-way fired soaking pits go into operation in Texas, where men make big investments and expect big returns

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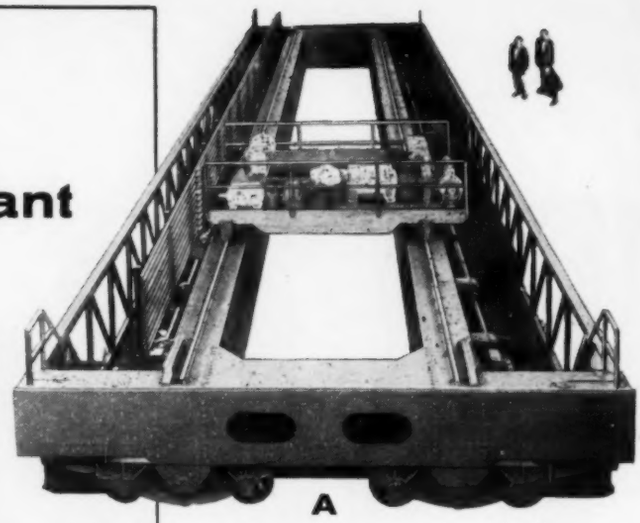
STEEL MILL EQUIPMENT

Get the Crane You Want
. . . turn to
SHAW-BOX



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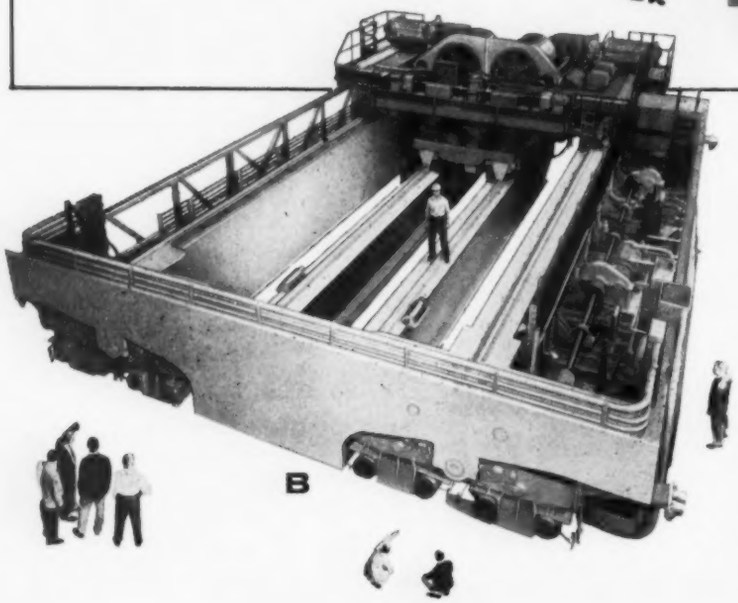
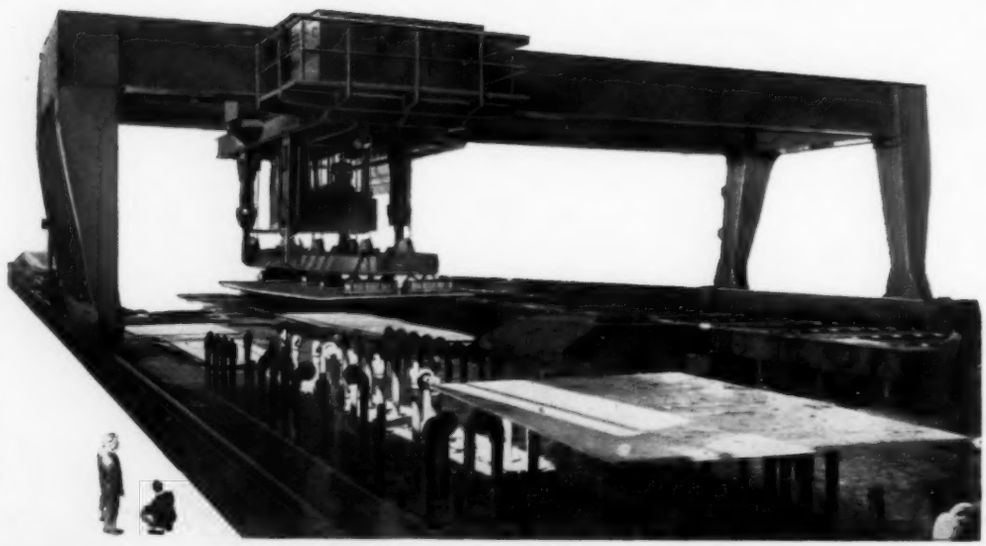


B

"Shaw-Box" Cranes are built exactly to specifications — your own or AISE Standard Specifications No. 6. Whether your plans call for a plate or slab handling crane, a soaking pit carriage, or a ladle crane, the long experience and vast facilities of Shaw-Box can save you time, trouble and money.

Make sure your next mill crane has the strength and rugged construction essential for 'round the clock service — plus economical operation. One of our engineers will gladly discuss specifications and tell you of our standard AISE designs for 15 to 200-ton cranes. Your inquiry is invited.



C

The pictures: **(A)** *25-ton, 100-foot span mill crane.* **(B)** *Ladle crane that handles 200 tons of molten steel in 90-ton ladle.* **(C)** *Plate handling gantry with lifting magnets. All have exclusive Shaw-Box structural, mechanical and operational advantages that assure reliable performance.*

"Shaw-Box"® CRANES

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

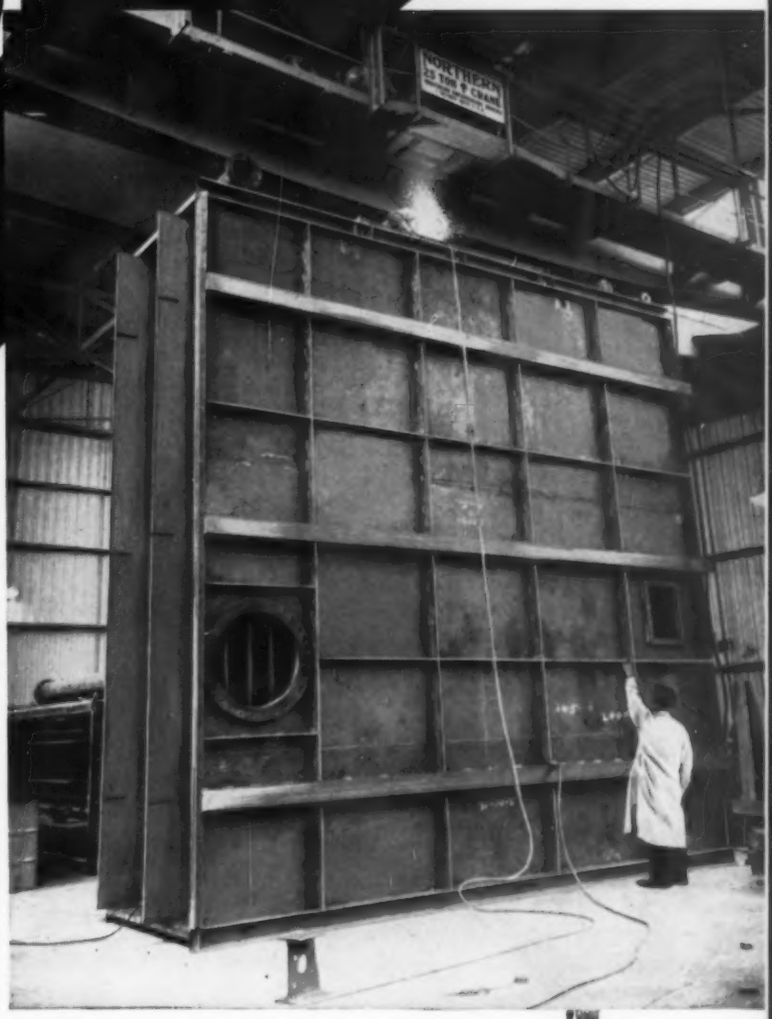
MANNING, MAXWELL & MOORE, INC.

SHAW-BOX CRANE & HOIST DIVISION, MUSKEGON, MICHIGAN

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Makers of 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

Two Miles of Pipe

in this FORTY-TON PACKAGE

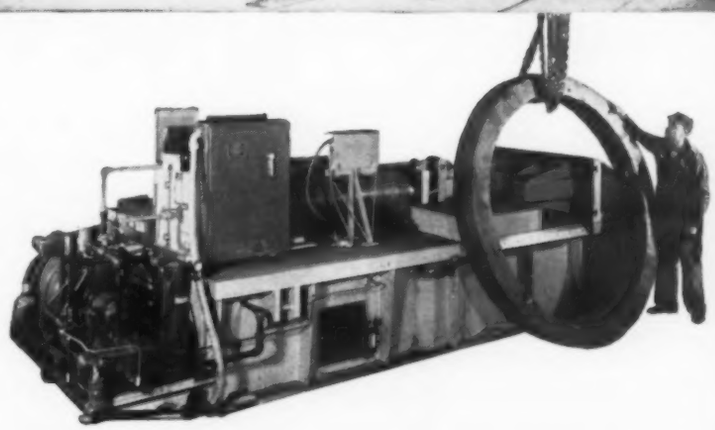


Completely Assembled, Welded and Tested by McGREGOR-MICHIGAN

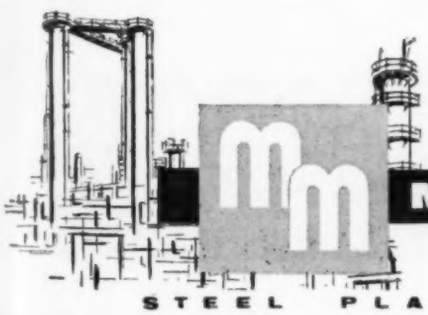
Sorry, we can't show the contents of this hefty box. It's our customer's design. But we *can* tell you each of four assemblies required approximately 10,000 lineal feet of 2″ extra heavy pipe, hydrostatically tested at 600 psi pressure. Shipment was made the McGregor-Michigan way—*on schedule*. This is one of the first sizeable jobs produced in our new Heavy Fabrication Plant which is equipped with the most modern equipment for bulkier and heavier work. Our Main Plant continues to turn out welded and riveted plate fabrications in both mild and alloy steels, such as steel mill charging buckets, ladles, furnace doors, ingot cars—chemical and petroleum processing towers, tanks, jacketed kettles—machine bases, diesel engine beds, heat exchangers, autoclaves, stacks—and an endless variety of other industrial equipment.

Something different in fabrication service is illustrated. It's our new six hundred ton horizontal press for cold-forming heavy bars, channels, conveyor rails and other structural steel members. The 67″ I.D. gear blanks shown are SAE 6150 steel, of 6″ x 6″ cross section, formed and then welded into an accurate ring. After welding, joints are cobalt-bomb x-rayed. Such equipment permits us to offer you close tolerance forming to almost any configuration with no heating or reheating (depending on nature of material), simplified dies, faster service and lower costs.

Please send prints or specifications for prompt quotation on your next fabrication job, or write for brochure illustrating our facilities and production.



New 600-ton "Bulldozer" — M-M designed and built horizontal forming press.



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McGREGOR-MICHIGAN CORPORATION

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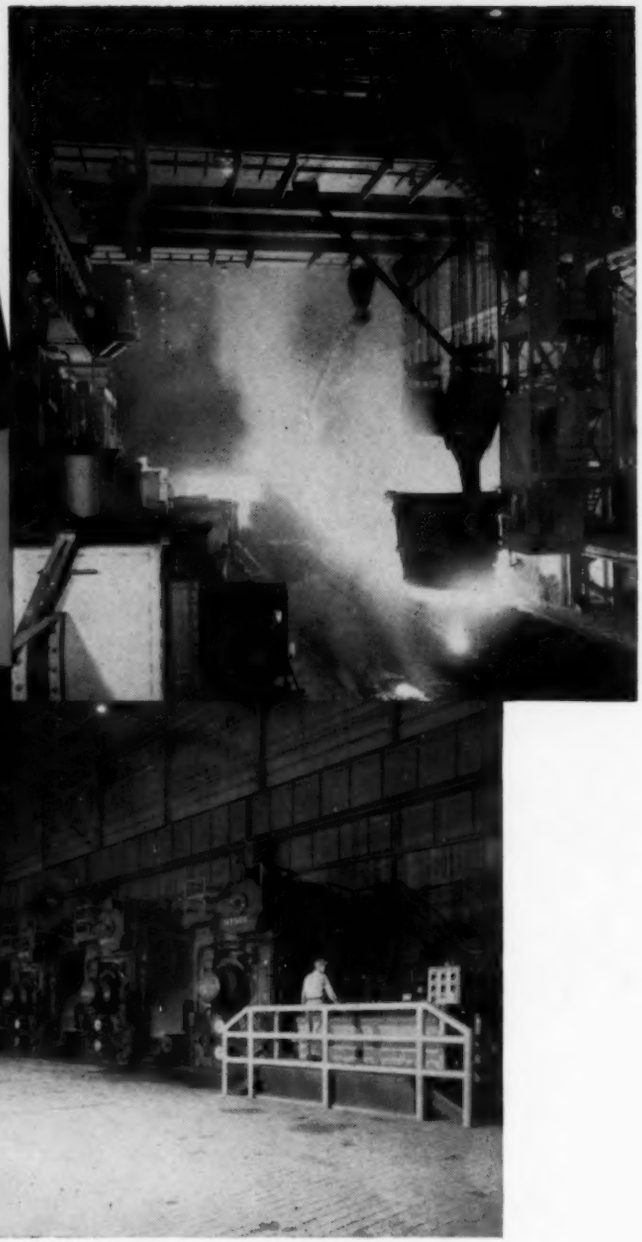
TRINITY 2-2400

STEEL PLATE FABRICATING AND WAREHOUSING

OVER 20,000 BEARINGS ARE LUBRICATED AT FAIRLESS WORKS BY

Trabon

LUBRICATION SYSTEMS



PHOTOS COURTESY U. S. STEEL CORPORATION

The following wide range of equipment at U. S. Steel's new Fairless Works is lubricated around the clock by TRABON *positive* centralized lubricating systems: Wellman Ore Bridge; E. W. Bliss Hi Scale Breakers; Arthur G. McKee Blast Furnaces; Atlas Ore Transfer Cars; Wean Combination Line; Alliance Cranes; Cleveland Cranes; American Bridge Cranes; Wellman Charging Machines; Dravo Ore Unloaders; E. W. Bliss 80″ Pickle Line; Mesta 45″ Slabbing Mill; Mesta 80″ Hot Strip Mill; Morgan 10″ Merchant Mill; Continental 40″ Blooming Mill; United Billet Mills; Morgan Scale Yard Crane; E. W. Bliss Cold Mills.

This installation of TRABON systems, automatic and manual, assures each bearing point accurate lubrication as frequently as it is required.

Write for our detailed literature for further information on TRABON versatile, trouble-free lubricating systems.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

Equipment News...

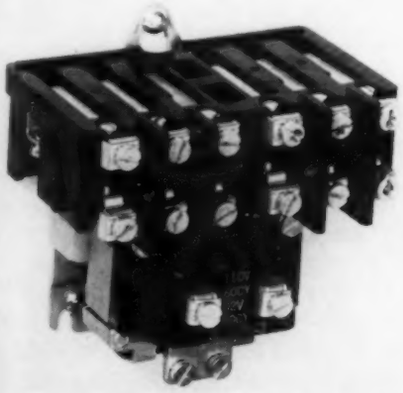
IN-LINE RELAY

▲ A new six pole in-line 10 ampere relay (NEMA Type A1B) designed for applications such as machine tools and control panels is now available from the General Electric Co.'s General Purpose Control Department.

The new unit increases flexibility and conserves panel space by reducing the number of extra relays necessary in automatic control systems. A new saddle-type terminal permits wiring from four directions with either plain wire or crimped-on terminal connections. The relay is available in both standard and latched-in forms.

All terminals of the new machine tool relay are accessible from the front of the unit. Other features designed to help cut installation cost by simplified wiring are captive clamps and large panhead screws on the terminals. More strength for the terminals is provided by a new molding for the stationary contact block.

The relay's coil helps reduce the chance of coil damage due to slipping screwdrivers or failure caused by



moisture, oil, or cutting fluids. A rolling motion of the contacts assures complete contact reliability.

A permanent air gap eliminates any malfunction resulting from residual magnetism. The new six pole in-line relay has silver contacts which are easily replaced. General Electric engineers said tests indicate that this machine tool relay will maintain a trouble-free average life of 20 million operations under normal conditions.

The new relay is available in 2, 3, 4, and 6-pole models and in all voltages and frequencies up to 600 volts, 60 cycles.

The machine tool relays contacts can be easily changed from normally open to normally closed or vice versa without additional parts. The new unit can use the same size mounting screws (No. 10-32 Max.) as size 0 and 1 contactors.

CONTINUOUS UNLOADER OPERATING AT CLAIRTON

This continuous coal unloader is now in operation at U. S. Steel's Clairton Works, replacing two coal hoists formerly used to unload barges. Three continuous bucket lines lift the coal from barge to plant where crushing facilities are available if needed to reduce the coal to a 3-in. maximum size. The coal then takes a 453-ft conveyor ride to one of four 1500-ton mixing bins. Continuous sampling determines the bin to which the coal is delivered, and the coal is again sampled as it leaves the bins. Automatic self-proportioning feeders send the mixed coal on another conveyor belt ride from the bins to bunkers mounted above the batteries. The new unloader replaces No. 1 and No. 2 bucket hoists, leaving two still operating. No. 3 Hoist will continue to handle coal washed at the mine, and No. 4 Hoist will unload unwashed coal. Four additional mixing bins, now under construction, will further increase Clairton's coal mixing capacity.

RADIAL WHEEL FAN

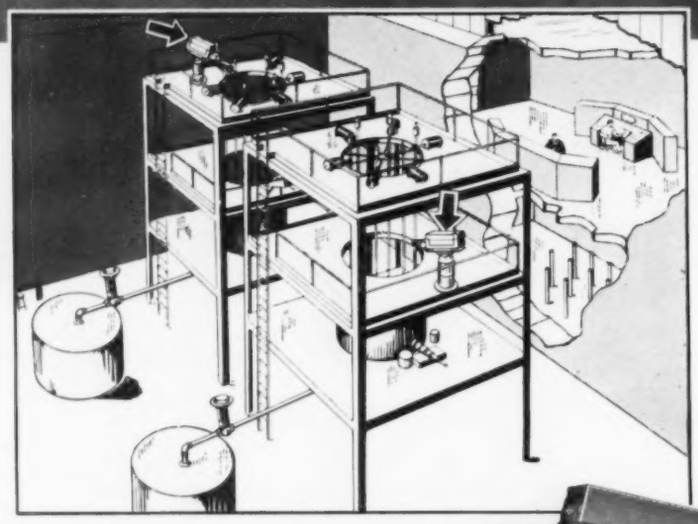
▲ A new radial blade fan by Buffalo Forge Co. has high-volume, high-pressure characteristics that make lower first cost possible on many applications. Called the Type "CR" Fan, it offers high mechanical efficiency—above 78 per cent—over a broad range, and is also highly suitable for handling dust-laden air. These characteristics are the result of inlet-to-outlet streamlining as well as the new radial blade design.

The inlet is a smoothly curved bell shape to allow air entry with absolute minimum turbulence, and the characteristics of this radial blade fan permit optimum performance with or without inlet guide vanes. For accurate volume control, the fan is available with variable inlet vanes of curved, cantilevered design, with no center ring to impede air flow, and with the linkage mechanism completely out of the air stream. Thus, performance is not reduced when the fan is supplied with this volume control.

The inlet bell matches the deep-drawn wheel flange to form a true half-circle entry path into the wheel with no obstructions or flat spots. The radial blades, rigidly welded to the wheel flanges and centerplate, curve smoothly forward at the inlet, while the hub is extra-large and uniformly tapered. Here again, sources of air loss and abrasion have been minimized. For unusually abrasive service, renewable welded-on wearing strips and beads can be provided.

The new fan design also goes beyond the usual concept of outlet

Diamond "UtiliVue"
(WIRED TELEVISION)
used in NUCLEAR REACTOR STUDIES
at Battelle Memorial Institute



Arrows indicate remotely controlled "UtiliVue" Cameras that SEE experimental nuclear reactor cores.

"UtiliVue" Monitor is built into control console in separate control room where experimental nuclear reactor cores can be WATCHED in perfect safety.

"UtiliVue" pedestal enables camera to be rotated 320° and tilted 90° by remote control from console. Zoom lens (also controlled from console) brings objects into focus at widely varying distances from camera.

The "UtiliVue" is invaluable whenever there is the need for actually SEEING what is happening where it is impossible or impractical for the human eye to watch directly. There are installations of Diamond Industrial TV that have been in continuous operation since 1946. For further information, get in touch with your Graybar Distributor or use the coupon below.

7406

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"FIRST IN INDUSTRIAL TELEVISION"
ELECTRONICS DEPT., P.O. BOX 56NN
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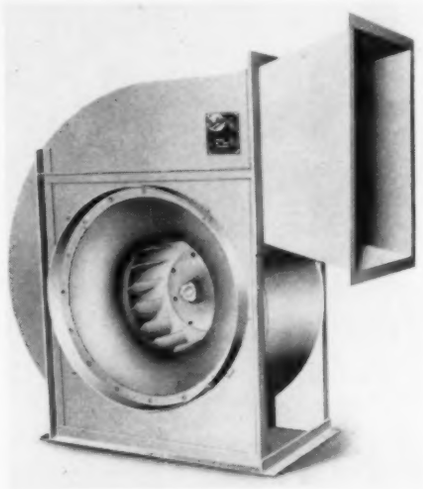
Address_____

streamlining by the addition of a divergent outlet. Fan outlets have hitherto been a barrier to efficient air flow into the duct, because of the sudden change from velocity at fan cutoff to static pressure in the duct, which causes turbulence. The new outlet provides a gradual diverging path from cutoff to duct, permitting an easy, gradual change to static pressure. In addition to the type CR



in radial wheel type, "BR" and "DR" radial blade fans are offered. The "BR," with wider and closer-spaced blades, is a higher capacity, lower pressure type; the "DR," with narrower and deeper blades, is a higher pressure type.

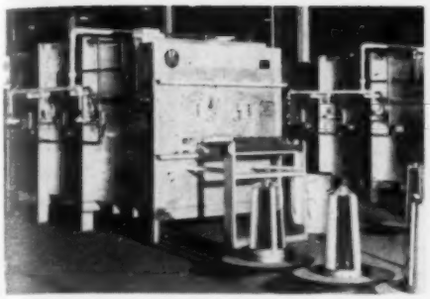
NARROW STRIP MILL

▲ Recently developed by Stanat Manufacturing Co., Inc., is a low cost 4-high reversing cold strip mill specifically designed to fulfill moderate output requirements in the production of close-tolerance and thin-gage strip up to 8 in. wide.

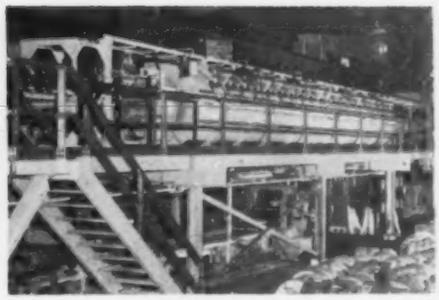
Designated Model TAL-625, the new unit processes both ferrous and non-ferrous materials such as carbon and stainless steels, beryllium copper, titanium, and aluminum alloys. The mill operates at speeds up to 500 fpm and holds thickness tolerances as close as plus or minus 0.0001 in. consistently.

Rapid roll changing, within 20 minutes, is facilitated by the backup drive employed which also offers the important advantage of change in work roll diameter without affecting the linear rolling speed of the mill. To handle a .125 in. to 0.001 in. range of strip, work rolls from 2½ in. down to ¾ in. diam can be employed.

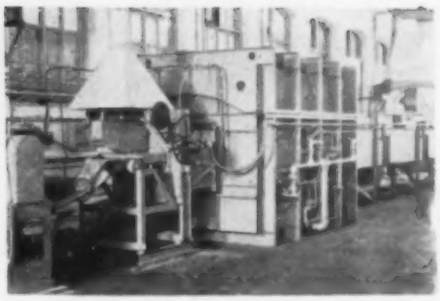
Backup rolls are 8 in. diam, work



An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.

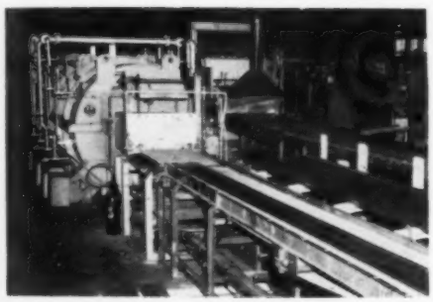


Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.

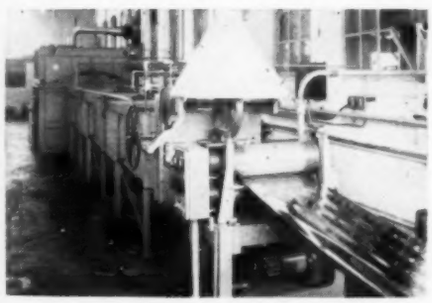


Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

Bright Annealing Stainless



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.



Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

Tubing, Strip, Wire, Stampings and Other Stainless Steel Products

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

Submit your production furnace problems to experienced EF engineers — it pays.

THE ELECTRIC FURNACE CO.

GAS FIRED OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

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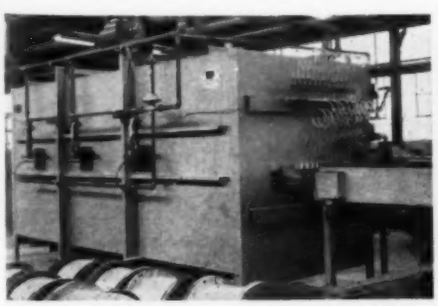
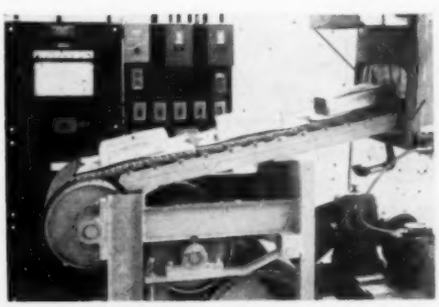
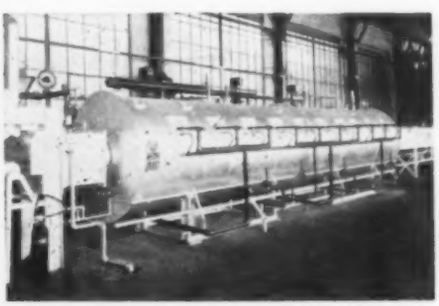


Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



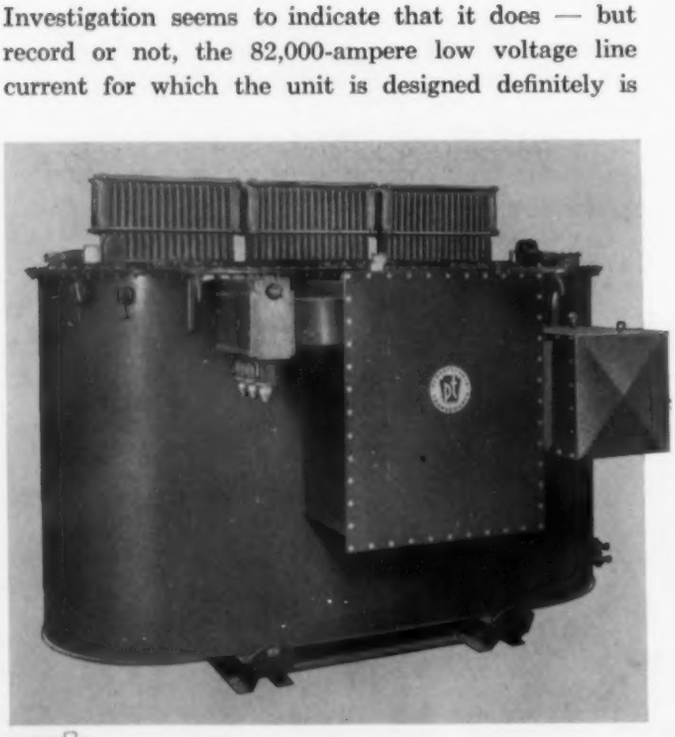
Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.

Does this PENNSYLVANIA FURNACE TRANSFORMER set a *High Current Record?*

Investigation seems to indicate that it does — but record or not, the 82,000-ampere low voltage line current for which the unit is designed definitely is one of the highest current ratings ever provided for a furnace transformer in this country.



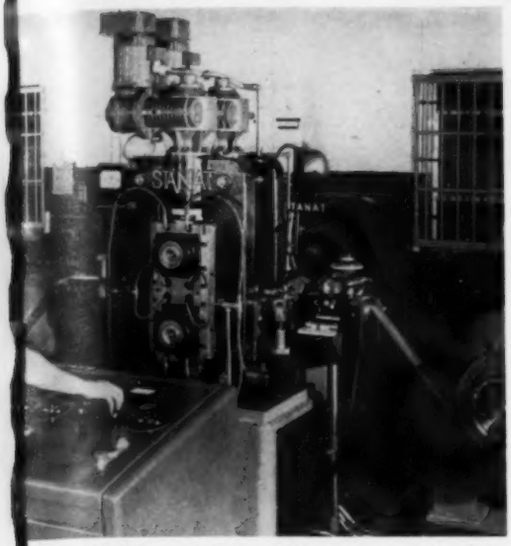
This extremely high current can be delivered at the future transformer rating of 21,300 kva. Now rated at 16,000 kva (with a maximum L.V. line current of 61,600 amperes), the three-phase unit has provisions for the addition of forced-oil cooling equipment to supplement the present water cooling and achieve the higher kva rating.

The transformer has a high voltage rating of 13,200 delta volts, and a low voltage rating of 250 delta volts with a full-capacity tap range in 10-volt steps down to 150 volts. The high L.V. line current results from the high kva and the fact that the lowest low voltage tap is at full capacity. The various low voltages are accomplished by means of a motor-operated, remote-controlled tap changer in the H.V. winding.

Pennsylvania now has designed and built furnace transformers ranging from 250 through 25,000 kva, and from 3175 through 82,000 amperes. Why not put this furnace transformer know-how and experience to work for you?

PENNSYLVANIA TRANSFORMER COMPANY

A McGraw Electric Company Division **CANONSBURG, PA.** Greater Pittsburgh District



High precision mill features backup drive which permits changing of work roll diameter without affecting linear rolling speed.

rolls are 2½ in. diam (maximum) and both are available in either an 8 in. or 10 in. face width. Roll wipers and run-in and run-out tables, equipped with adjustable side guides, are provided on the machine.

Roll frames are constructed of high tensile steel castings, capable of taking loads far in excess of usual requirements with minimum deflection. Rolls are driven through torque arms from a totally enclosed pinion stand. Elimination of roll marks is achieved by hardened, alloy steel herringbone gears running in an oil bath and loads are carried by heavy duty, tapered roller bearings which insure long life. Heavy duty, mill type universal joints connect the torque arms to the rolls and pinion stand.

Radial loads are taken by heavy duty needle roller bearings, equipped with bronze cages, and axial movement is controlled by ball thrust bearings. Backup roll bearings have a maximum separating load capacity of 150,000 lb.

Roll adjustment is made by a power screwdown system operating at a rate of ⅛ in. vertical travel per minute and consisting of two 1 hp gearmotors controlled electro-magnetically for individual or simultaneous "up" and "down" operation.

Two coiler stands, equipped with solid or collapsible drums, are driven by individual motors at winding speeds synchronized with the mill motor to obtain constant tension regardless of line speed or coil buildup.

The mill is powered by an infinitely variable speed drive, comprising one 20 hp mill motor and two 20 hp coiler motors. Electrical equipment also includes an operator's control panel, a packaged power unit, and electronic tension controls.

Other important features of the mill are a bearing lubricating oil circulating and filtering system, a strip coolant circulating system, quick-acting strip bridles, and "Flying Mike" thickness gages calibrated in 0.0001 in.

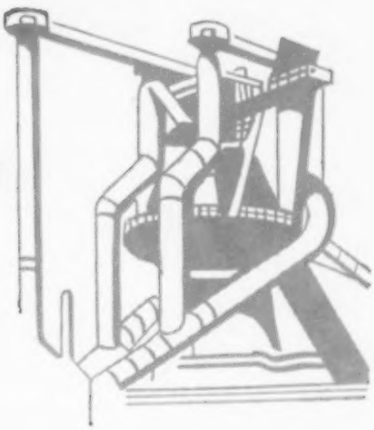
A compact, fully wired package unit requiring no elaborate foundations, the mill with coilers occupies only 10 ft x 8 ft of floor space.

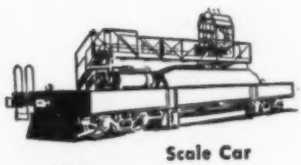
ELECTRONIC GAGE

▲ A new high-speed electronic gage team consisting of a small electronic pickup cartridge for incorporating in new and existing gages and precision instruments and a portable electronic amplifier is available from the Sheffield Corp.

(*Please turn to page 240*)

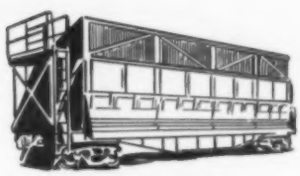
WHEREVER *performance* **COUNTS**





Scale Car

100-ton Ore Transfer Double Compartment, Bottom Dump



Coke Quenching Car

Atlas Cars are built to resist the high wear factors of continuous service handling abrasive materials. Extra factors of safety in brakes, controls, visibility, and signal devices are incorporated for foolproof service.

Each car is engineered to meet the operating needs of the plant where it will be used.

ATLAS
CAR & MFG. CO.
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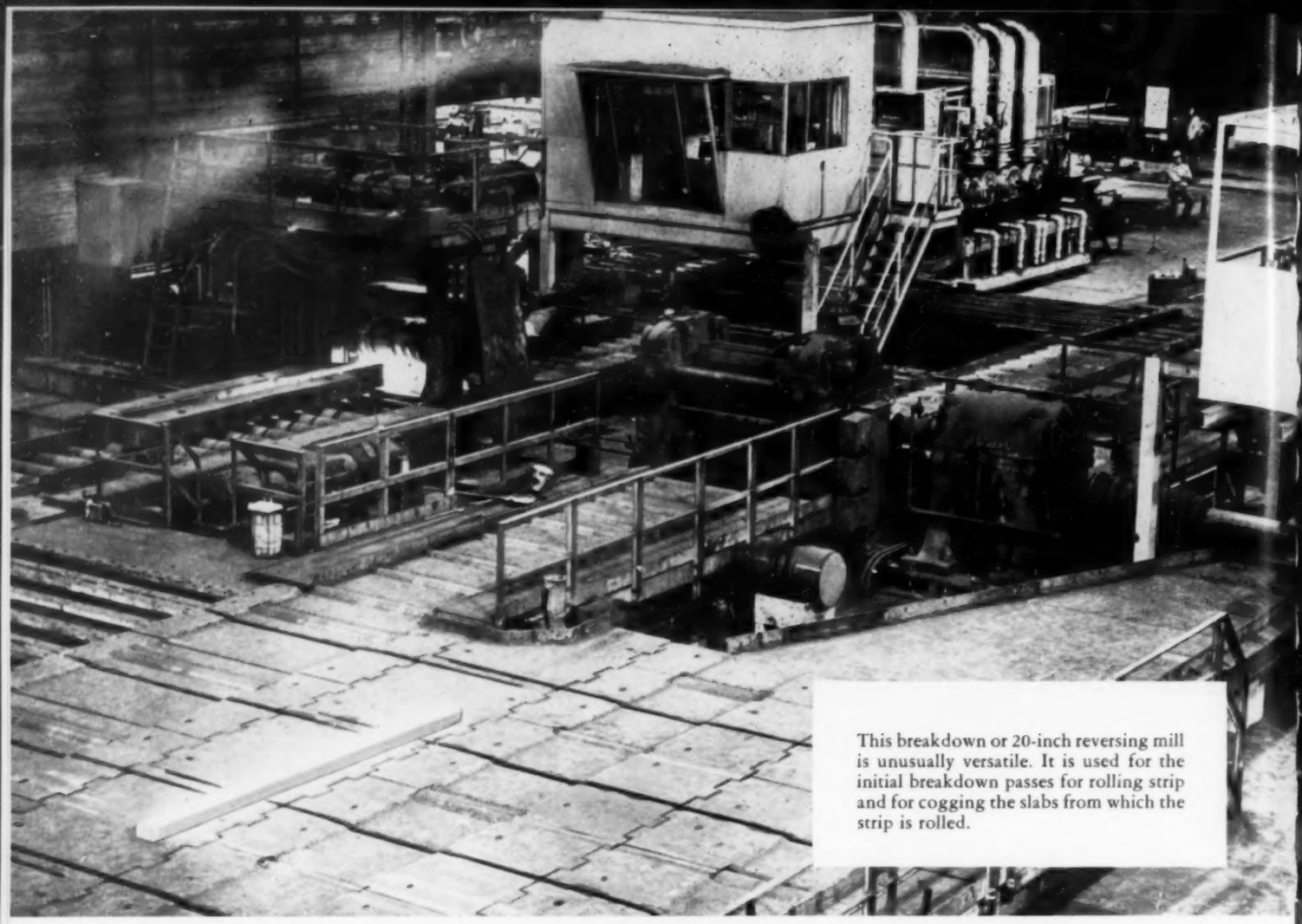
Consult Atlas for your Steel Plant Cars

ENGINEERS AND MANUFACTURERS SINCE 1896



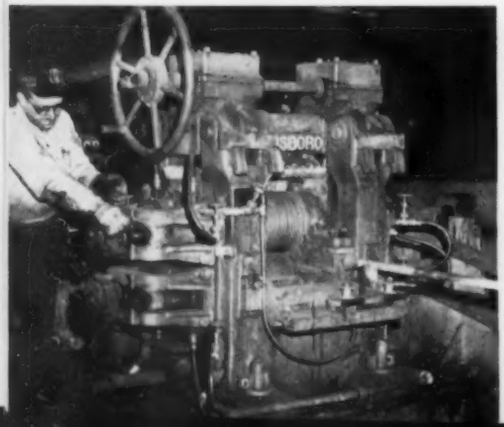
This breakdown or 20-inch reversing mill is unusually versatile. It is used for the initial breakdown passes for rolling strip and for cogging the slabs from which the strip is rolled.

Steel producer picks new BIRDSBORO bar, strip and rod mill design to meet "Expansioneering" Demands

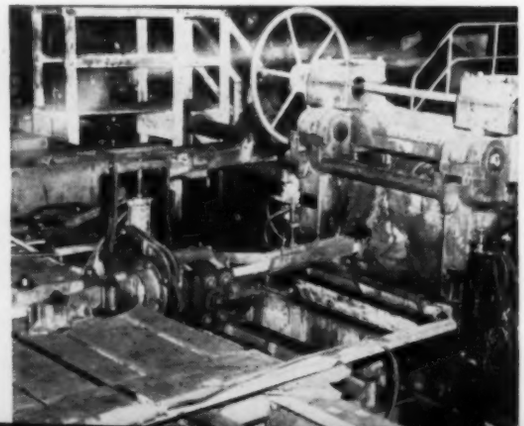
This steel maker needed more than a "standard" mill, since its specialty steel business required unique mill flexibility to render maximum customer service. Special tolerances and highest product quality must be produced quickly, in profitable quantities, with as many automatic operations as possible.

BIRDSBORO was called in on the job because an exacting combination of engineering features was required. Ruggedness, plus the versatility to permit many refinements in the production of steel bar, strip and rod, was a major requirement. Once again, Birdsboro engineers delivered exactly what the producer ordered plus the extra touches that resulted in maximum production efficiency, both in quantity and quality.

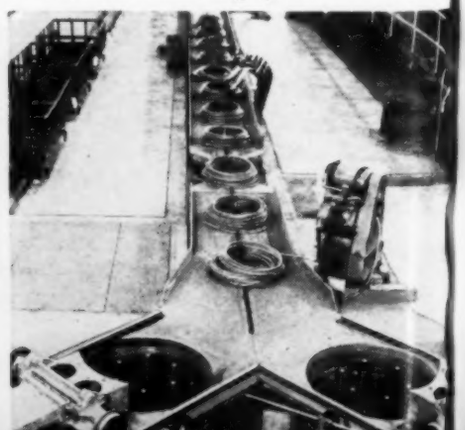
Close size and shape control is gained to micrometer accuracy through end thrust adjustment on this finishing stand.

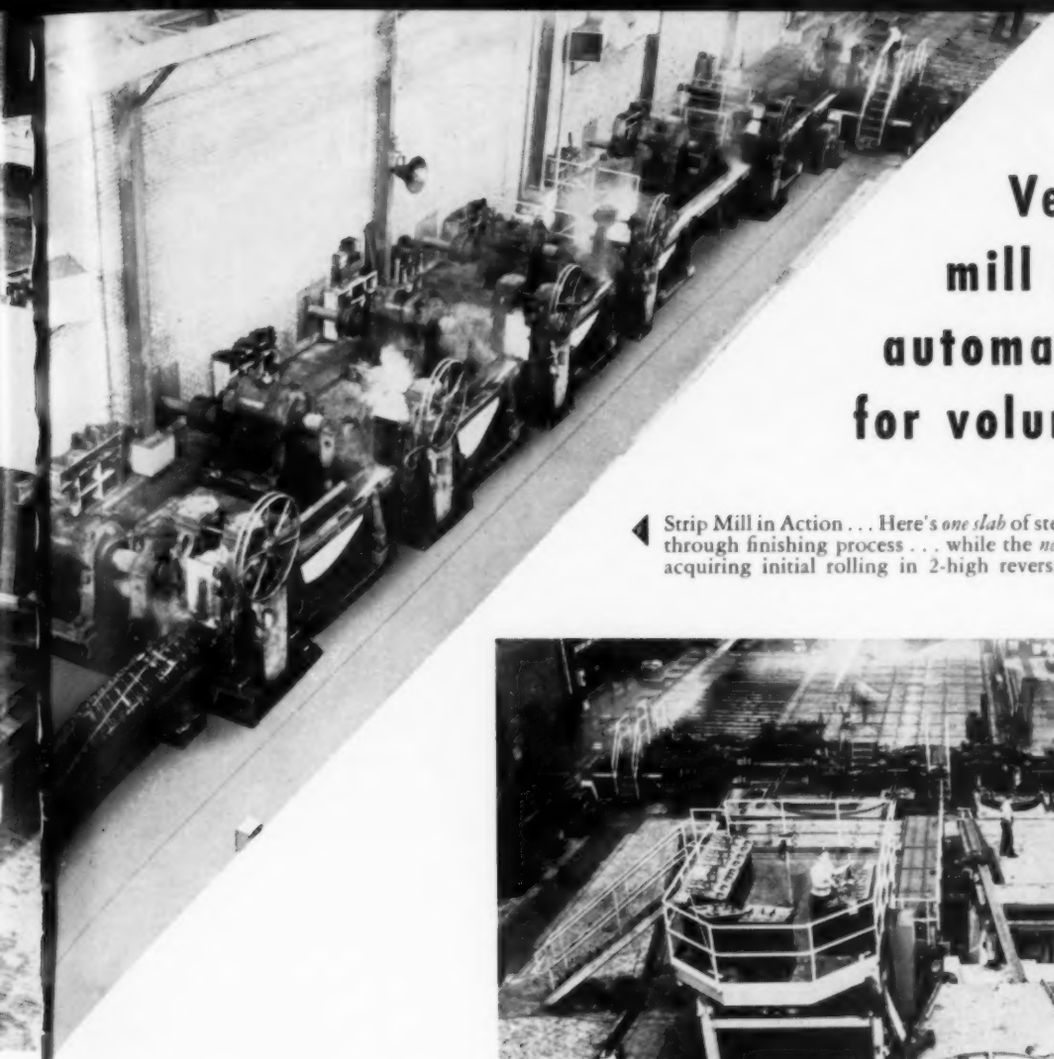


This oval turn-up device on the rod and bar mills eliminates manual stranding common in older types.



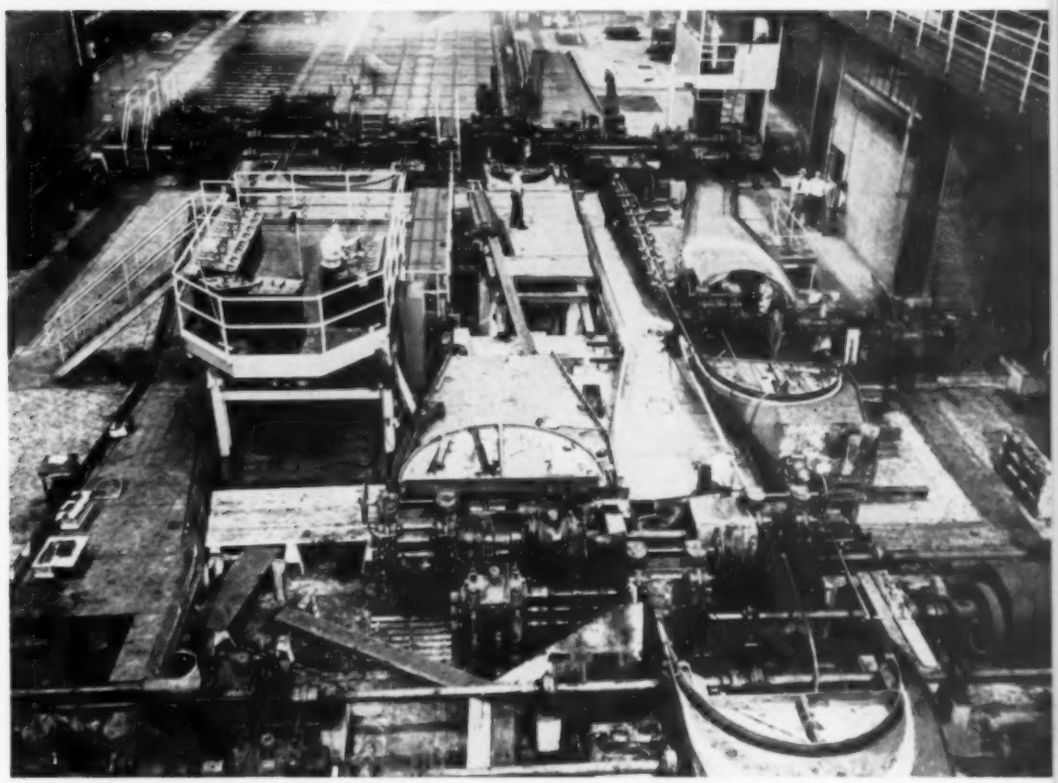
Conveyor table, delivering coils of rods to loading point. Coils are moved separately for individual cooling which helps produce uniform structure in annealing cycles.





Versatile 3-way mill provides speed, automation and accuracy for volume production

Strip Mill in Action . . . Here's *one slab* of steel going through finishing process . . . while the *next slab* is acquiring initial rolling in 2-high reversing mill.



The Continuous looping method is used to roll rods. The rod at upper left is in initial breakdown, while the loops to the right are in the finishing stage. Loops are closely controlled in a small area, aiding in size control and permitting compact design installation.

Not just machines, but ideas, too!

. . . Ideas applied to mill machinery problems that can provide not only a solution, but production advances . . . the advances that will keep your plant profit picture bright for years to come. While your "expansioneering" is still in the planning stage, call in a BIRDSBORO representative. He and the experienced staff that backs him have the design ideas you can profitably apply to your operation.

DESIGNERS AND BUILDERS OF:

- **STEEL MILL MACHINERY**
- **HYDRAULIC PRESSES** *(Metalworking and Extrusion)*
- **CRUSHING MACHINERY**
- **SPECIAL MACHINERY**
- **STEEL CASTINGS**
- **Weldments "CAST-WELD" Design**
- **ROLLS: Steel, Alloy Iron, Alloy Steel**

MM-52-56

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., **Main Offices in Birdsboro, Pa.** District Office: Pittsburgh, Pa.

New York Office: **Engineering Supervision Co.,** 120 West 42nd Street, New York 36, N.Y.

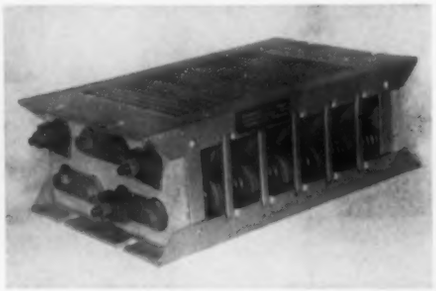
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co. 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

GUYAN MACHINERY COMPANY

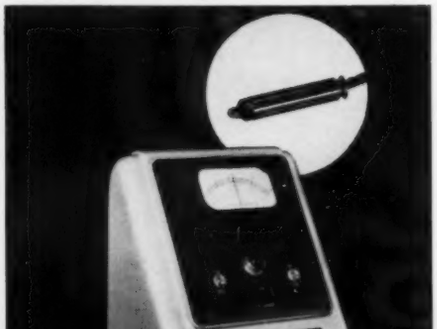
LOGAN, W. VA.

(Continued from page 237)

Each unit has a number of new and outstanding gage features. The cartridge is small, compact, easily mounted. It requires no pickup calibration, being set by locating in setting fixture only. It can be used with the full range of Accutron amplifications from 1000 to 1 up to 40,000 to 1.

The amplifier has dual amplifications that can be switched from one to another without requiring realignment of the indicating meter mechanism.

The size of the cartridge (3/8 in. diam by 1 7/8 in. long) makes it an ideal size-sensing element for a large variety of gaging devices. The cartridge has a total stylus travel of approximately .110 in. Pre-travel is approximately .005 in. Depending upon amplification, effective gaging travel is up to .004 in. with an over-travel of approximately .100 in. A positive stop at the end of plunger over-travel protects the cartridge against damage. The cartridge is sealed at both



ends to prevent foreign particles from affecting the operation of the stylus.

The electronic amplifier is portable and lightweight and operates on 110 v, 60 cycle a-c. It is unaffected by line voltage fluctuations from 65 to 150 volts. It has a specially designed electronic circuit with built-in voltage compensation that permits extra-fast indication without drift or shift in amplification.

The amplifier is available with dual amplifications of either 1000/-2000; 2500/5000; 5/10,000; 10/20,-000; or 20/40,000 to 1. Amplifications within each dual range can be switched from one to another without realignment of the indicating meter mechanism.

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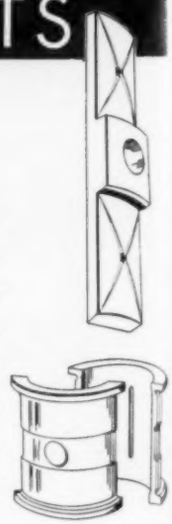
for the best
BRONZE PARTS



FLOOD CITY Bronze Parts are best . . . best fitting . . . best wearing . . . all expertly machined from the best grade of hard, wear-resistant bronze or to your particular specification bronze.

For years Flood City has furnished quality bronze parts at a savings in metal weight and machining costs to a variety of industries

We welcome your inquiries concerning quotations and delivery on your bronze parts needs. Our reply will be prompt — and there is no obligation.

Be sure it's the BEST -specify FLOOD CITY

SERVICE FC FIRST

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BRASS & ELECTRIC CO.
JOHNSTOWN, PA.
PHONE: Johnstown 8-1281

In heavy-duty drives . . . demand assurance of

permanent, accurate shaft alignment

Sturdy Housing of heavy, close-grained gray iron provides rigid support of shafts. Designed so that all parts can be removed without disturbing base or draining oil.

It's yours...with these other "plus" performance features—in LINK-BELT Parallel Shaft Drives

Under the shocks and overloads that are often imposed upon parallel shaft gear drives, rugged housing construction is compulsory if shaft alignment is to be maintained. That's why Link-Belt adds special reinforcement at points of greatest stress . . . has developed this design expressly for endurance in heavy-duty service.

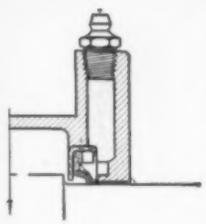
Write for Book 2619 on this broad line with ratios to more than 300:1. Or get first-hand facts from your nearest Link-Belt office or authorized stock-carrying distributor.

14,243

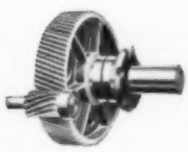
LINK-BELT

ENCLOSED DRIVES

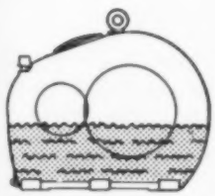
Ball and Roller Bearings are of ample size and capacity to withstand shock and overloading.



Grease-Lubricated Seals on all input and output shafts prevent entrance of dirt, water.



Precision Gears and Shafts are arranged to provide high reduction ratios in small space.



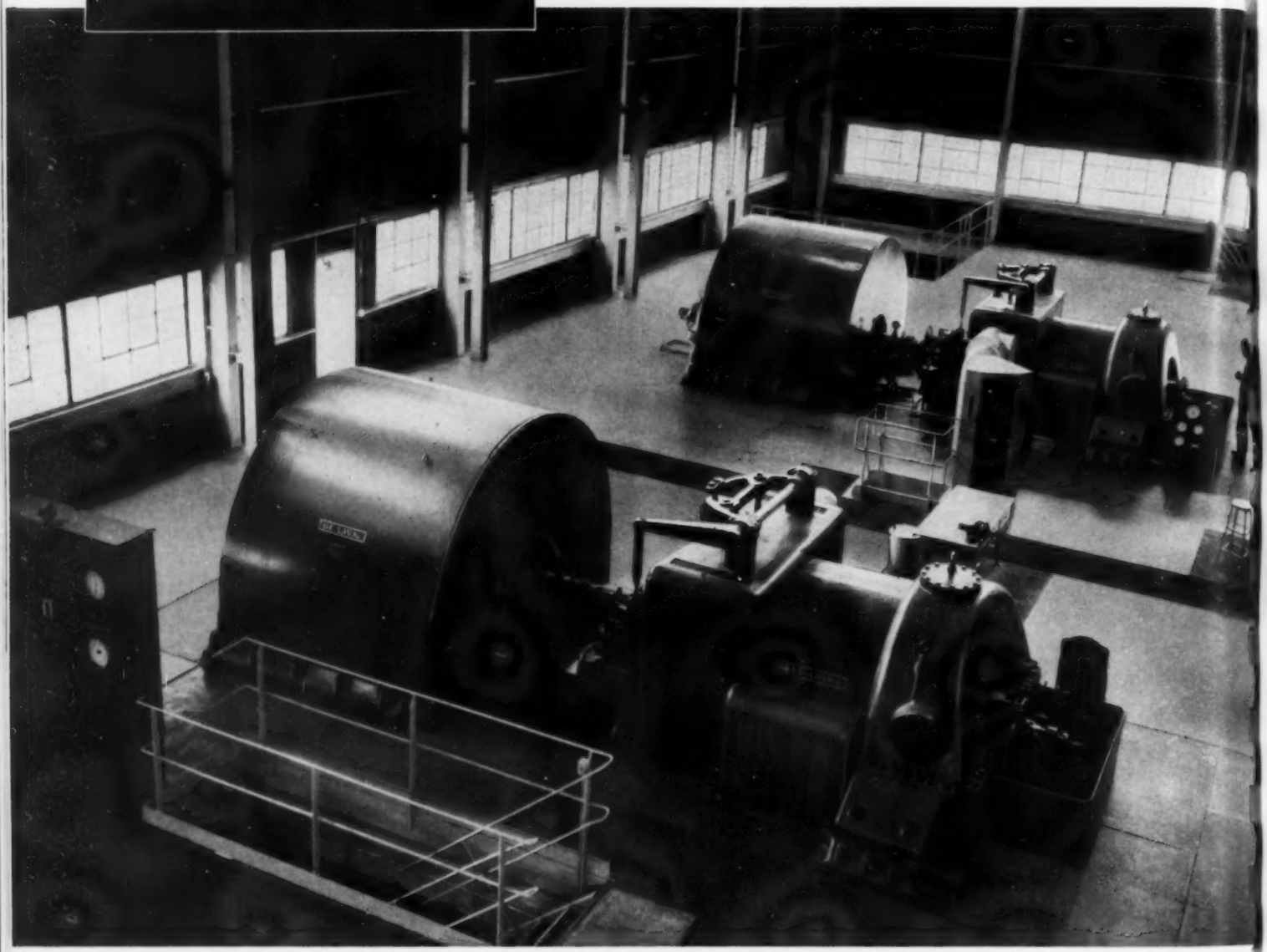
Automatic Splash Lubrication reliably supplies oil to all gears and bearings.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

DE LAVAL

BLAST FURNACE BLOWERS

deliver 110,000 cfm each for McLouth Steel



These two De Laval turbine-driven centrifugal blowers do a round-the-clock job in the McLouth Steel plant, Trenton, Michigan. Each has a rated capacity of 110,000 cfm of air; discharge pressure is 30 psig. Each is driven by a 12,400 hp, 2950 rpm De Laval steam turbine operating under steam conditions of 600 psig, 825 F with 2″ hg.

De Laval compressors are designed individually for each application to assure maximum efficiency and range of operation. Construction is rugged throughout. Casings and perfectly balanced rotors are built to take punishment. All parts are precision-made to limit gages. Materials are selected which will best meet the particular conditions of corrosion, pressure and temperature.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

Send for Bulletin 0504

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

870 Nottingham Way, Trenton 2, New Jersey

DL 340

HYDROLUBE FLUIDS

▲ Carbide and Carbon Chemicals Co., Division of Union Carbide and Carbon Corp. has developed two new fire-resistant hydroluble fluids.

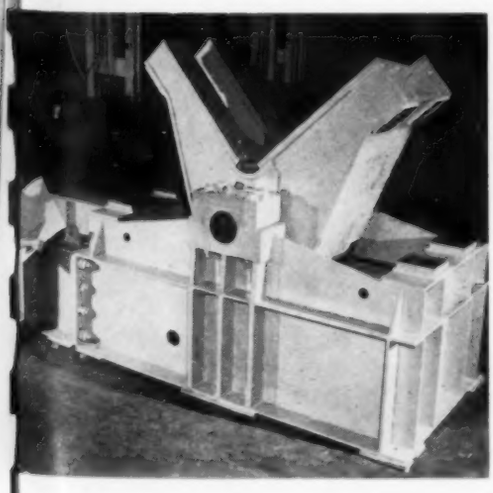
These new hydrolubes have outstanding corrosion and wear resistance. Laboratory tests and actual industrial service over a two-year period have shown that the wear resistance of the hydrolubes is markedly improved and is in the same general range as petroleum hydraulic oils. These tests have also shown improved vapor phase corrosion protection for ferrous metals over that of previous formulations.

Hydrolube fire-resistant hydraulic fluids are now widely used in applications where petroleum oils would present a fire hazard. Many serious fires have occurred when flammable petroleum oils from ruptured hydraulic lines have been ignited by sparks, hot surfaces, or flame. With water-base hydraulic fluids, this hazard is minimized since they are essentially non-flammable as long as the recommended water content is maintained.

The new hydrolubes have many desirable performance properties. They have no harmful effects on packings or seals and are characterized by excellent shear stability, high

COIL FILTER

This huge tilter for steel coils is given one final inspection at Link-Belt Co.'s plant at Colmar, Pa. Destined for the Continental Foundry and Machine Co., Kloeckner, Germany, the tilter is designed to upend or downend steel coils weighing up to 60,000 lb and measuring up to 72-in. outside diameter. It will be located at the end of a two-strand conveyor. Coils will be removed by either truck or overhead crane. The tilter, which weighs 45,829 lb, was furnished through Wean Engineering Co.



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HEAT-PROOF COATINGS

Brush MARKAL Coating on a piece of metal and apply the direct flame of torch until metal is red hot. You will find that the *protective coating has not been impaired.*

MARKAL Coatings will give you complete protection against steam, corrosion, scaling, oxidation at extreme heat—temperatures up to 2100°F. Easy to apply!

MARKAL COMPANY
3087 West Carroll Avenue • Chicago 12, Illinois

Write for complete technical information and free sample . . . important that you state conditions.

The Mark of Quality Protection—MARKAL!

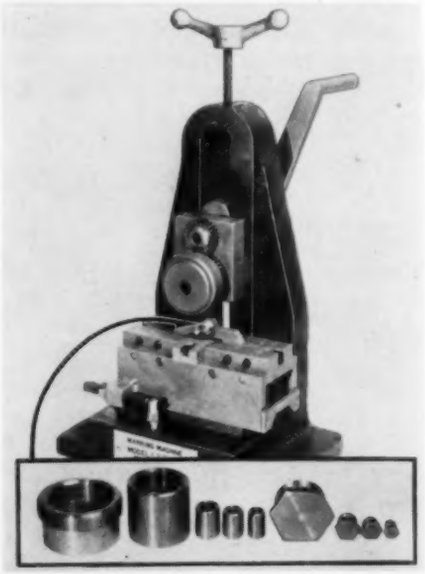
viscosity indexes, and low pour points. Ordinary filters are suitable when these fluids are used and leakage losses are low. Hydrolubes are safe to handle because they are formulated from relatively safe and widely used chemicals.

STAMPING FIXTURE

▲ A new modification of the GRD stamping fixture has been developed by M. E. Cunningham Co., for marking around the circumference of sleeves and on the edge of hex plugs of various sizes. This new Style B Fixture uses cradles for circumference of sleeves and a special table for marking hexes.

Components of the fixture include: (1) cast steel housing, (2) cradles and table for holding parts being marked, (3) roller marking die and (4) gear-mounted handle. As the handle is turned, the gear arrangement causes the die to move across the piece held in the cradles or table.

For marking on the edge of a hex, the table is positioned over cradles. Adjustable gages are provided to make a nest for holding plugs; screw adjustment on side sets nest in proper position for making contact with the die. A spring return moves the table to loading position after the marking is completed.



LIFT TRUCK

▲ The Yale & Towne Manufacturing Co. has introduced an improved dust protected, gasoline powered industrial lift truck to provide trouble free materials handling in locations containing atmospheric abrasives.

There are five main features on the truck which materially reduce the harmful effects of abrasive dusts and lint to mechanical and electrical parts. Cases on record show that engine life can be increased by as much as five times by proper dust protection.

Since abrasives in the air include a diversity of consistencies, a tandem air cleaning system filters air going into the carburetor. Air passes first through an improved dry type precleaner, then through a heavy duty oil bath cleaner. The precleaner is mounted on top of the truck hood so that the primary engine air intake is remote from engine air contamination caused by the fan.

The oil filter in the improved dust protection system is of a heavy duty type. A heavy duty air filter is also provided on the crankcase breather pipe.

The bottom of the truck is protected by a deflector plate which reduces the possibility of foreign par-

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Don't risk faulty cooling plates during your next campaign. Replace with Lawrence Copper Bosh and Mantle plates for dependable, trouble-free, long run performance.

Made from pure copper with the know how gained from 68 years in serving many of America's large steel plants, Lawrence Cooling Plates always last through the campaign. Send your specifications today.

Highest Quality and Dependability Since 1888

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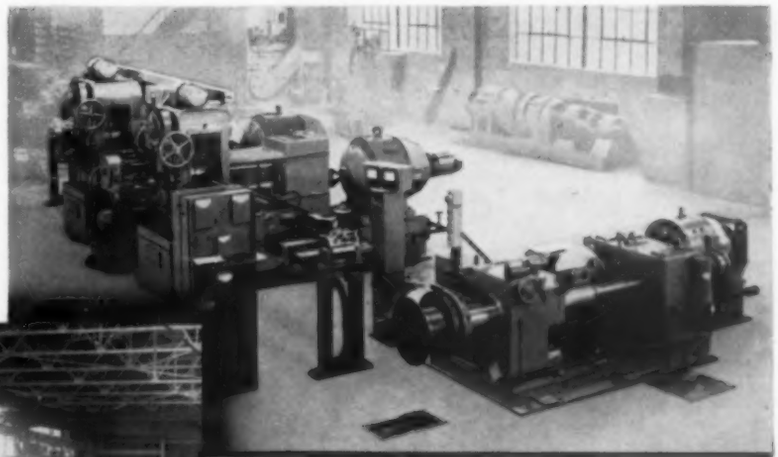
Waterbury Farrel Wire Flattening MILLS IN ACTION

Pictured here are a few of the many Wire Flattening Mills designed and built by Waterbury Farrel. Each installation was custom-engineered to fit the production requirements of each individual customer.

Whether your requirements call for a single or multiple stand mill, Waterbury Farrel can supply you with a reliable production unit that will prove to be a profitable investment.



▲ Two Stand Tandem Wire Flattening Mill at National Electric Coil Co., Columbus, Ohio. Speeds up to 1000 feet per minute.

Two Stand Tandem Wire Flattening Mill recently installed at John A. Roebling's Sons Corp., Trenton, N. J. Speeds up to 1500 feet per minute. ▼

▲ Three Stand Tandem Wire Flattening Mill in production for Anaconda American Brass Co. Ltd. (Subsidiary of the American Brass Co.) New Toronto, Ontario, Canada. Speeds up to 1800 feet per minute.

Three Stand Tandem Wire Flattening Mill installed at General Electric Co. in their Pittsfield Works. Speeds up to 2500 feet per minute. ▼

Write today for your free copy of Wire Flattening Mills, Cir. No. 731-R.

WATERBURY FARREL

THE WATERBURY FARREL FOUNDRY & MACHINE CO. Waterbury, Conn.

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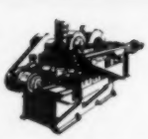
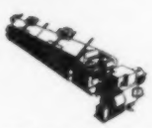


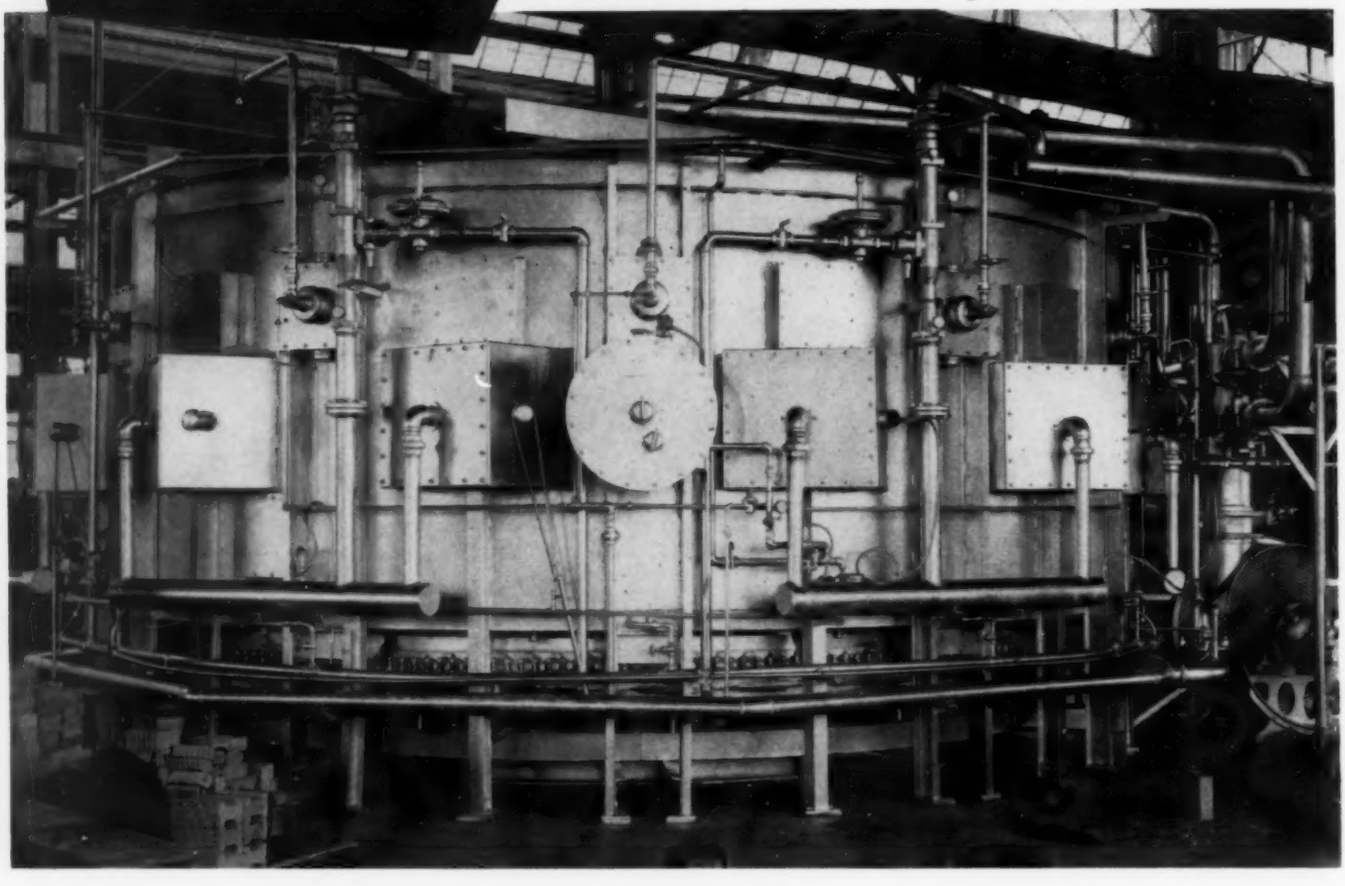


Bolt, Nut & Screw Machinery • Power Presses • Rolling Mill Machinery • Wire Mill Equipment • Sendzimir Mills and other Special Machinery

WATERBURY FOUNDED 1851 FARREL

WF-32

TAYCOR provides excellent hearth life *in this Lithium Company Furnace*



TAYCOR® (Corundum-base) Refractories have given exceptional service in this Lithium Recuperative Atmosphere Rotary Furnace*. Used for scale-free heating of 28-lb. billets to 2275-2300° F., the furnace is operated 5 days a week at a very high rate of production.

Because of excellent resistance to heat and abrasion, TAYCOR brick were used for the hearth. The hearth remains smooth and even after continued service in production over an extended period. Burner blocks and tunnels were formed of TAYCOR Ramming Mix, which has proven excellent after a prolonged period of service.

Based on this experience, TAYCOR hearths are being used in the majority of continuous furnaces built by The Lithium Company.

TAYCOR is an ideal refractory for forge, welding, heating and heat-treating furnaces where abrasion and mill scale attack at high temperature cause early refractory failure. Put TAYCOR to a test in your furnaces. May we supply you with further information?

** Manufactured by The Lithium Company Newark, N. Y.*

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TAYLOR ZIRCON · TAYLOR SILLIMANITE

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
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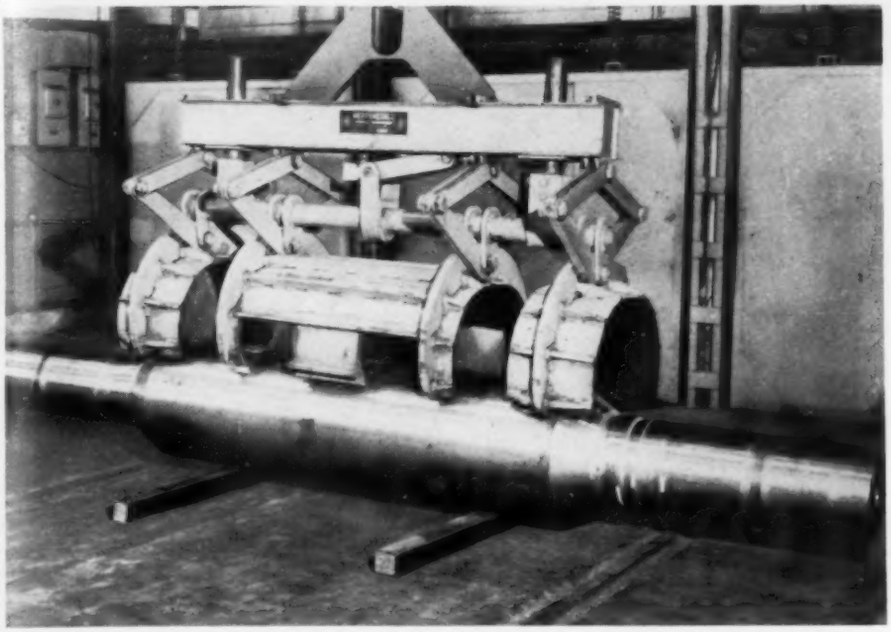
AUTOMATIC TONGS CARRY ROLLS AT HOMESTEAD



Specially-designed automatic tongs are lowered over a work roll at the Homestead Works of United States Steel Corp. The tongs, manufactured by Heppenstall Co., consist of four scissors-type jaws, suspended from a steel beam, with an automatic locking and unlocking device in the center.

ticles on the floor from being drawn up into the engine compartment. This deflector plate can be easily removed for truck servicing.

Finally, the generator and voltage regulator are completely enclosed for the preservation of commutator surfaces and extended brush and contact life. The protection on these two units is the same as that used on Yale trucks recently granted Underwriters' Laboratories GS approval.

CONTROL CENTER

▲ Introduced by Clark Controller Co. is a new line of control centers featuring space saving, accessibility, and rigidity. The Bulletin 6200 Type W control centers are available in Type A, B, and C construction with NEMA 1 or NEMA 1-gasketed construction.

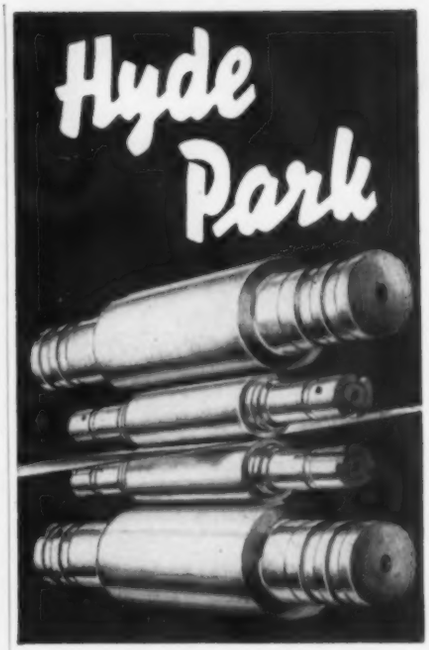
Space occupied by the units is reduced because they are narrower than previous designs. Space required around an installation of these control centers is also reduced because no access from rear or sides is required for inspection, maintenance, or removal and replacement of any components including horizontal and vertical bus.

The basic vertical unit of the new line is only 20 in. wide, yet it can accommodate six NEMA Size 2 starters with ample wiring space. Similar space savings can be obtained in other units of the line, and with other control elements.

No hinge wiring is required, and the door can be closed and latched to protect a compartment from which control elements may have been removed.

Book Reviews . . .

"Our Nation's Water Resources—Policies and Politics" by Admiral Ben Moreell has recently been published by The Law School, University of Chicago, Chicago, Ill. The book contains 266 pages, 9 x 6 in., is cloth bound, and sells for $3.50. The book contains five lectures delivered by Mr. Moreell at the University of Chicago, April and May 1956: "Federal Water Policies—Past and Present," "Federal Organization of Water Resource Development," "Federal Development in Navigation, Reclamation, and Flood Control," "Federal Power Developments," and "The Hoover Commission Task Force on Water Resources and Power—Findings and Recommendations," which contain strong advice against the freezing of water uses of the future by indiscriminate and ill-advised, short-term proposals, and presents



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The Red Circle on the Roll is the Hyde Park mark of Quality. Hyde Park makes rolls for every type mill.

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Moly Rolls
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for
Finer Finish, Longer Life
and Greater Tonnage
specify Red Circle

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS • ROLLING MILL MACHINERY
GREY IRON CASTINGS

Exposed to direct flame, Okotherm-insulated wires continued to operate for over 8 months on these coke oven charging cars.

Okotherm-Insulated Wires lasted 8 months here

Until recently, one of the nation's largest commercial coke producers in the southeast had to replace at least one cable leading to the vibrators on its coke oven charging cars *"every shift, three shifts a day, thirty days a month."*

These replacements were necessary because the cables had to pass through flames toward the end of each charging operation. The company reported that this replacement cost them an average of $247.50 a month.

Eight months ago, they installed Okotherm-insulated wiring on the vibrators and lights of these cars. Since that time, no replacements have been required. The total wire and installation cost was less than $200. The "per month cost" already averages less than $25.00.

If you have a high ambient temperature cable problem, it will pay you to investigate Okotherm-insulated cables. Suitable for operation up to 200C, Okotherm-insulated cables are moisture- and ozone-proof and have high dielectric strength. Single and multiple-conductor power and control cable constructions are available.

NEW— Okotherm-insulated cable *with aluminum sheath.* Eliminates conduit. New Bulletin IS 1088 gives all details. Write for it today to The Okonite Company, Passaic, N. J.

OKONITE OKONITE SINCE 1878 ***insulated cables***

2953

an over-all policy for the constructive development of all our water resources.

"The Economics of Soviet Steel" by M. Gardner Clark has recently been published by Harvard University Press, Cambridge 38, Mass. The book contains 400 pages, 9 x 6 in., is cloth bound, and sells for $7.50. Mr. Clark is associate professor in the School of Industrial and Labor Relations, Cornell University. This is his first book and is Russian Research Study 25. This book contains 16 chapters divided into four parts; production and investment, problems of specialization and scale, location and potential development, productivity. This study discusses these four problems and the solutions attempted by the Soviet Union, and also illuminates other questions regarding the relationship between Russian technological development and that of leading noncommunist countries; stressing the speed with which Soviet engineers are introducing Western and, particularly American inventions as explaining the rapid expansion of Russian steel production. The book is in English, numerous tables are employed, and several appendices present statistical data and more detailed analysis. A valuable feature is a list of Rusian steel plants and their products.

"Industrial Engineering Handbook" has recently been published by McGraw Hill Publishing Co., Inc., Industrial and Business Book Information Service, 327 W. 41st Street, New York 36, N. Y. This handbook is a compilation from well known contributors, with Harold B. Maynard, editor in chief. The book contains 1398 pages, 9 x 6 in., is cloth bound, and sells for $17.50. The handbook covers such phases of industrial engineering as function, methods, work measurement, predetermined-element-time standards, wage payments, control procedures, plant facilities and design, in sections of from 94 to 207 pages, and in addition, another section of over 300 pages presents other aspects of industrial engineering including estimating data, slide rule operation, curves and nomographs, office methods and standards, distribution methods and standards, storekeeping methods, safety, operator training methods, suggestion systems, cost-reduction procedures, operations research, preparation of effective reports, graphical-presentation methods, nonindustrial applications of industrial engineering, and fundamentals of automation. The data is presented with numerous substantiating line drawing illustrations and tables, etc.

"The Steel Skeleton — Volume Two: Plastic Behaviours and Design" by J. F. Baker, M. R. Horne, and J. Heyman, was recently published by Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. The book contains 408 pages, 7 x 10 in., is cloth bound, and sells for $12.00. This volume describes the investigations covering the parts of a structure that pass out of the elastic into the plastic range, with the result that a more simplified design method is possible which makes possible the direct and economical design of welded portal frames. Instability is given particu-

(*Please turn to page 262*)

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Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

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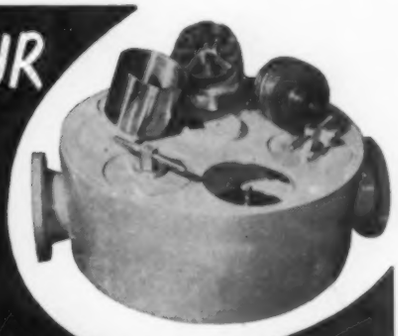

FERRO FILTER®

Magnetic Separators

help reduce costly maintenance on bearings, gears and pumps by removing rust, scale and fine steel particles worn off moving parts from lubricating oil systems.

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Brunswick Pike and Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

Above: Model 6-PA-6 made up of 6 permanent magnet separator assemblies for 8" pipe line.

Model PQ-6 for 3" pipe line available with screwed or flanged connections.

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For greater safety and economy, have your Alloy Sling Chains returned to either our Pittsburgh or Hammond plant for repair, inspection and testing, at nominal cost.

S. G. TAYLOR CHAIN CO., Hammond, Ind. and 3505 Smallman St., Pittsburgh 1, Pa.

FAST···LEGIBLE BILLET MARKING!

now made possible with the NEW

MODEL 701
PNEUMATIC
BILLET MARKER

This new, compact unit stamps ends of billets 4" x 4" or larger with a deep, legible mark as shown above. Unit is mounted on an I-beam track and powered by heavy duty air cylinder. Quick change type holder is kept in stamping position at all times without special guides.

WRITE for Data Sheet 613.

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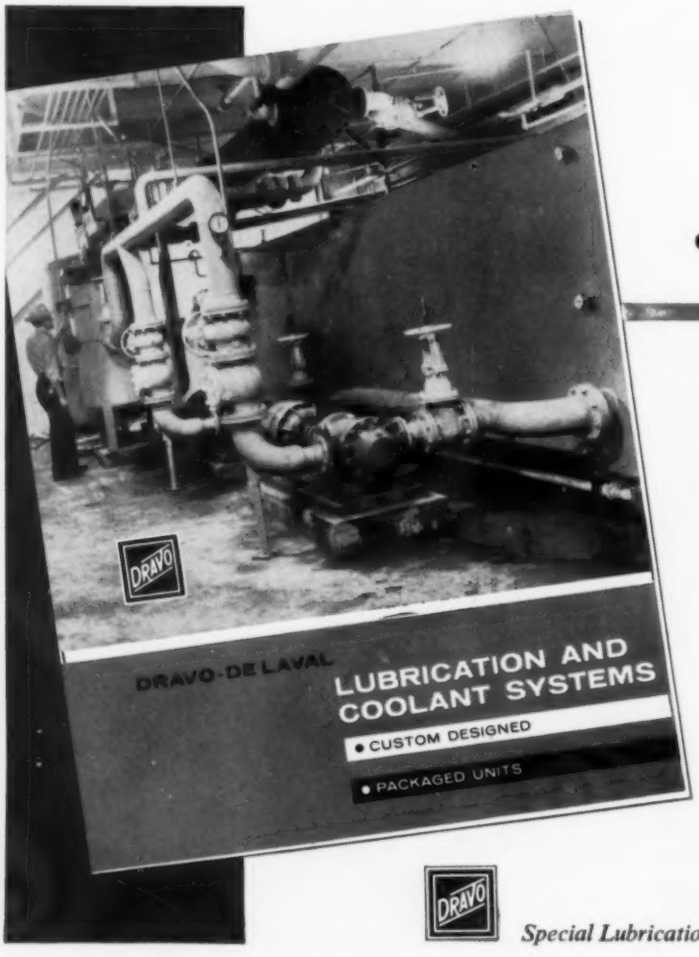

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DRAVO CORPORATION

Special Lubrication and Cooling Systems for mechanical equipment serving industry

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Bailey-built HEAT PROVER Analyzer

CONTINUOUS READINGS OF OXYGEN AND COMBUSTIBLES

The famous Cities Service HEAT PROVER Analyzer, formerly available only on loan, is now manufactured by Bailey Meter Company, and you can buy one outright. With this handy portable instrument, you can easily monitor the per cent of oxygen and combustibles in gases.

The continuous readings from a Bailey HEAT PROVER Analyzer enable furnace, kiln, and engine operators to correct combustion variables before costly losses are incurred. Although it weighs a scant 25 pounds, the HEAT PROVER Analyzer is the key to maximum combustion efficiency. With it, the operator can determine the proper proportion of fuel to air at any time.

The two meters on the analyzer show per cent by volume of oxygen and combustibles on either a 20% range span or a more sensitive 4% range. Temperature of flue gases in degrees Fahrenheit is also shown.

Compared with involved, time-consuming Orsat measurements of flue gases, this new portable analyzer offers these advantages:

1. Simultaneous direct readings of oxygen and combustibles.
2. Negligible time lag between combustion change and reading change.
3. Continuous sampling, analysis, and readings.
4. Convenient measurement of temperature.

Ask your Bailey engineer how you can use this instrument to increase combustion efficiency. Or, write today for more information on how this new Bailey HEAT PROVER Analyzer can pay for itself practically at once. G-39-1

Flue gas analysis with a Bailey HEAT PROVER Analyzer at a furnace stack. Per cent oxygen and combustibles is shown continuously.

Instruments and controls for power and process

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In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

When all the shouting is over and the last campaign speech has been made, isn't this what all the struggle is really about?

You and your neighbors are going to march to the polls November 6 and settle things the American way.

Not by fists or by force, not with a penalty if you don't vote, or the secret police checking up to see if you did.

You'll vote because it's the thing to do.

Vote as you please, of course—but vote.

Vote for the party and the candidates you honestly believe will represent you best.

But also vote because you believe in this democracy of ours and you want to keep it the way it is—a country where you can have your say and nobody else can say it for you.

Everybody you know will be there.

We'll see you at the polls.

THE AMERICAN HERITAGE FOUNDATION

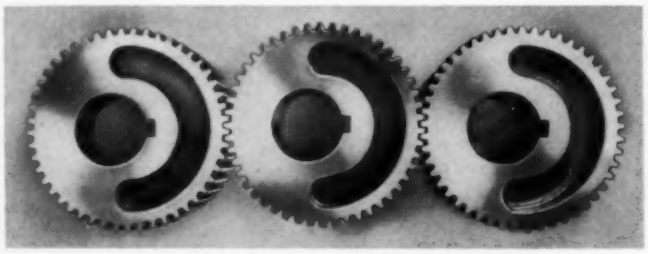
PUBLIC SERVICE ADVERTISING COUNCIL

VOTE NOVEMBER 6th!

Applying Gearing Effectively in the Steel Industry

by **Robert Ritzel**
Regional Marketing Manager, Denver
Western Gear Corporation

The requirements for gears and gear drives in the steel industry are both diverse and specialized. Only a company that possesses an intimate knowledge of the industry can provide the most effective answer to these requirements.

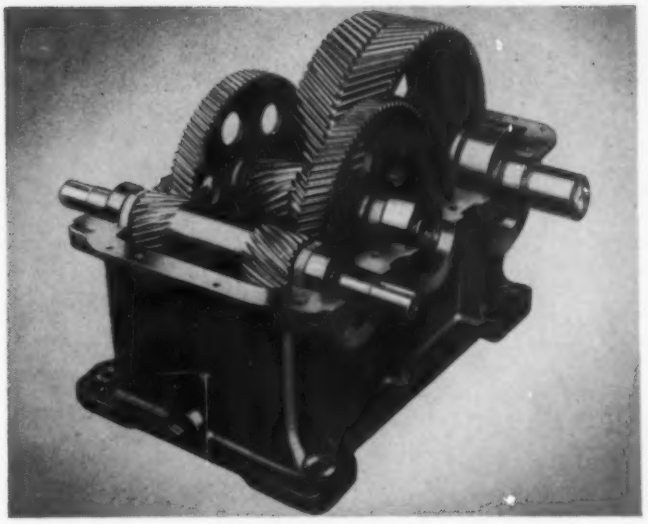


PRECISION ELLIPTICAL GEARS

Western Gear technicians after considerable research have developed a new concept of generating elliptical gears. By generating, the blank and cutter revolve together continuously with the cutter fed across the gear blank as it revolves. Previously elliptical gears were produced by a form cutter with its inherent inaccuracies. Our method insures a proper gear tooth profile, minimizes tooth to tooth spacing tolerances and produces each tooth normal to the true elliptical pitch line. This precision method has resulted in greater life and smoother operation.

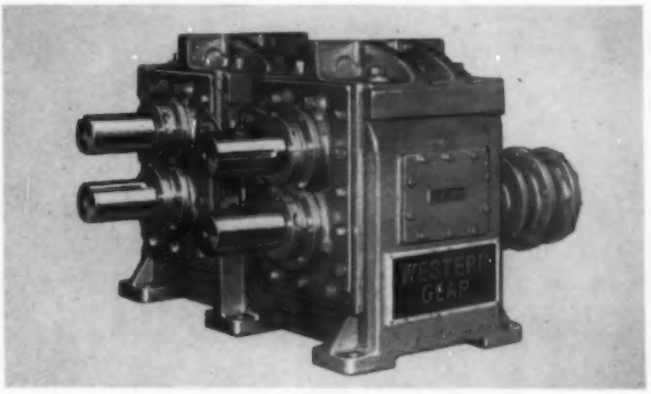
MITER GEARS

Based upon careful and continuous study of the industry Western Gear has gained recognition for many improved applications of gears. The photo shows gearing made for mill table rolls. Today miter gears for mill table rolls are made of carburized alloy steel and also through hardened and later flame hardened .40 to .45 carbon alloy steel. Western Gear maintains its own heat treating department to insure internal control of all heat treating processes.



SPEED REDUCERS

Over the years the steel industry has depended upon Western Gear to supply its speed reducer needs. Western Gear speed reducers are found on main mill drives and auxiliary drives in mills throughout the country. Some of the main applications are on slitter drives, shears, ingot buggy drives; also on cranes, for the hoist, trolleys and bridge drives as well as all types of conveyors. Capacities range from 1 to 10,000 HP. Western Gear speed reducers are of balanced design. Roller-type antifriction bearings carrying only radial loads and all thrust loads are cancelled out due to opposed helix angles, thus giving unrivalled, troublefree service.



PINION STANDS

Mill pinion stands or combination speed reducer and mill pinion stands built by Western Gear meet the rigid steel industry requirement for custom designed and manufactured equipment. Western Gear has supplied units to steel mills around the world ranging in capacity from 5 to 5,000 HP. Conservative design with compact, rigidly constructed gear cases, precision cut gearing and carefully selected bearings are all a must in the manufacture of a Western Gear mill pinion stand.

Western Gear over the years, with the close cooperation of the steel industry, has accumulated know-how about the many problems that face the steel mill engineer. We invite your inquiries on any power transmission or gear applications that you have and you can be assured that your inquiry will be given the personal attention of one of our key steel mill specialists. Please send your inquiries to Western Gear Corporation, P.O. Box 182, Lynwood, California.

Research

...helped make a good P&H Overhead Crane better

Ever since P&H built its first overhead crane back in the latter-day 1800's, its team of engineers has been working steadily to improve each successive model.

Improvements come about through research—painstaking, careful design—hours of testing and discarding and testing again. It's the same kind of research that contributed to the first major improvement in overhead crane design—the original P&H three-motor crane.

This research continues at P&H every day of the year. It's your guarantee that the P&H Overhead Crane you buy is the finest made.

Make sure you get the benefits of P&H research in your next overhead crane installation. Our engineers will be glad to work with you on your building plans — to show you how you can get the most out of your P&H Crane. A note on your letterhead will start them thinking for you immediately.

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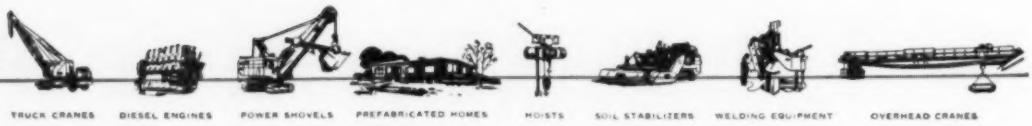

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Sub-micron fumes are the *really tough* problems in gas cleaning. These fumes cannot be economically or effectively controlled by conventional cleaning devices.

However, the CHEMICO P-A VENTURI SCRUBBER is proving its success in solving these *really tough* problems in more than 150 commercial installations and in more than 70 pilot investigations.

The table lists some of these commercial installations. All of these *really tough* problems and many more are being solved with complete satisfaction to users of P-A VENTURI SCRUBBERS.

PROCESS	DUST OR FUME	INSTALLED CAPACITY CFM
Incinerator—Flue Fed	Fly Ash	32,000
Incinerator—Sodium Disposal	Na_2O	9,000
Incinerator—Industrial	Radioactive Dust	6,000
Dry Ice & CO_2 Plants	Amine Recovery	72,400
CO_2 Gas for Process	Fly Ash	500
Boiler Flue Gas	Fly Ash & SO_2	4,300
Enamel Frit Furnace	Dust & HF	11,900
H_2SO_4 Concentrator	H_2SO_4	49,800
Copperas Roasting	H_2SO_4	34,250
Cobalt Ore Roasting	H_2SO_4	65,000
Chemico Wet Type Acid Plant	H_2SO_4	41,000
Chloro-Sulfonic Plant	H_2SO_4	600
Phosphoric Acid Plant	H_3PO_4	91,900
Phosphoric Acid Concentrator	H_3PO_4	194,000
Phosphor Copper Furnace	H_3PO_4	15,000
Smelting—Non-Ferrous		
Blast Furnace	Lead & Organic	12,000
Reverb. Furnace	Lead Compounds	23,500
Comb. Blast & Reverb.	Lead Compounds	7,000
Brass Furnace	Zinc Oxide	7,500
Ajax Furnace	Beryllium Fumes	4,000
Steel Plant		
Oxygen Steel Process	Iron Oxide	140,000
Blast Furnace	Coke & Iron Oxides	788,000
Zinc Sintering	Zinc Oxide	75,000
Wood Distillation	Tar Products	3,500
Na_2SiF_6 Dryer	SiF_4 & Dusts	700
Iron Chloride Concentrator	$FeCl_2$ & HCL Mist	40,000
Unknown	Carbon Black	1,700
Lime Kiln	Lime & Na_2O	18,000
Detergent Spray Dryer	Chemical Fume	250,000
Furfural Residue Burner	Fly Ash	36,000
Nodulizing Kiln	Manganese & Lead	25,000
Aluminum Pot Lines	Tar Fog, Fluorides	40,000
Carbide Furnace	Metal Oxides	1,000
Asphalt Plant	Rock Dust	80,000

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For Lines that Carry Hot Corrosive Gases

This W. S. Rockwell Monel metal, double disc, wedge locking type gate valve—in 36" x 42" and larger pipe size—was built for coke oven by-product lines. It controls the flow of hot gases containing a high percentage of corrosive sulfuric acid and ammonium sulfate.

The valve has a drain connection in the bottom, and a coupling in the bonnet for water sealing. Operation is by hand wheel (on floor stand) through a shaft and gears to valve stem; it may also be operated by hand wheel from above, or automatically by hydraulic, pneumatic or electric operator.

W. S. Rockwell valves are made in many types and materials of construction for handling air and gases, from sub-zero to 1600° F., cooling water, process fluids and granular solids. These are available in butterfly, slide, gate, swing gate, check and other types. Write for catalog.

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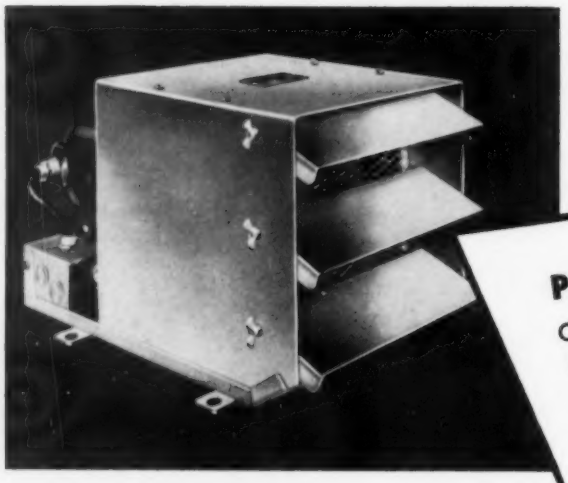
instant heat where you want it...WITH THESE TWO

P-G CONVECTION HEATERS



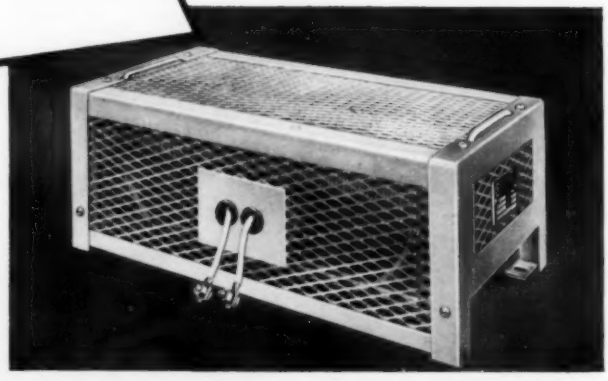
P-G Forced Convection Heater

Capable of moving a large volume of air with little noise. A 250 Volt D. C. Compound Wound Ball Bearing Motor of ¼ H. P. drives the fan. The heating circuit is controlled by a separately mounted 50-Ampere Magnetic Contactor energized thru a snap switch. The fan circuit is controlled thru a snap switch and contains a rheostat to vary the fan speed. Heating elements from 4 to 9 KW capacity, 230-250 Volts, D. C., are available.

P-G Natural Convection Heater

Ruggedly constructed, yet light in weight, they are easily portable by repair or construction workers. Ideal for permanent wall or floor mounting in crane cabs, etc. If a portable unit is desired, its disappearing handles may be used for ease in carrying. Made regularly in 3 to 6 KW capacity, 250 Volts, D. C.

TWO TYPES of HEATERS are available for industrial service. The heating element of both units is made of P-G Type T2, Chromium Steel Grids, which, because of their thin cross section, develop an unusually large heating area. A greater volume of warm air is so produced, and in addition, a more uniform heat distribution is obtained.



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"If you had asked me that question three months ago..."

"—I would have been ashamed to answer you. But today, I'm glad to say, we have a good Payroll Savings Plan—with 84.4% of our employees enrolled.

"Of course, we've always had The Plan—put it in during the war—but with changes in personnel and our failure to present the Plan to new employees, participation dropped to almost nothing.

"One day our State Director of the Savings Bond Division, U. S. Treasury Department, dropped in to see me. When he told me how far below average we were I asked him what we could do to bring it up. He gave me a complete campaign built around a person-to-person canvass that would put a Payroll Savings Application Blank in the hands of every employee, with the Treasury furnishing pay-envelope stuffers, posters and other literature. I was a little dubious about the personal canvass but our employees were enthusiastic, in fact, officials of our union volunteered to undertake the canvass. There was no pressure, no teams, no prizes—just the distribution of the Application Blanks. Our employees did the rest—84.5% enrollment.

"84.5% is a good enrollment but we are not going to rest on it. A number of companies are in the 90% bracket—that's our goal."

Your State Director, Savings Bond Division, U. S. Treasury Department, will be glad to help you install The Payroll Savings Plan, or build participation in an existing plan. Write: Savings Bond Division, U.S. Treasury Department, Washington 25, D. C.

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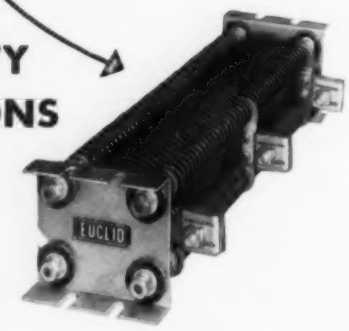
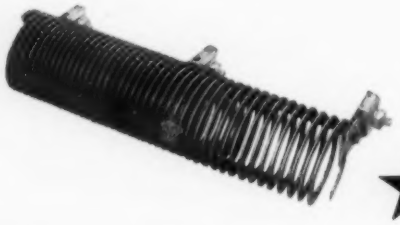
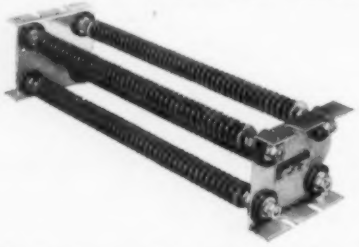


All Steel and Mica Construction provides a truly non-breakable resistor.

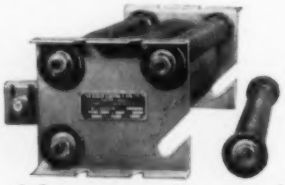


Continuous stainless steel edge-wound coil without joints eliminates hot spots, buckling and distortion.



Support rods on outside of coil permit unobstructed cooling air flow and compact design for smaller size and less weight per horsepower.

Exclusive slotted design



Slotted end frames permit removal and replacement of coil without disturbing rod assembly.

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Then, the Adams Separator creates a cyclone to efficiently remove the condensate . . . giving you cooler, drier air for your system.

Thousands in use throughout industry. It will pay you to find out all the details. Mail the coupon below today.

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Please send my FREE copy of Bulletin #711 on Adams Cyclone Separators and Aftercoolers.

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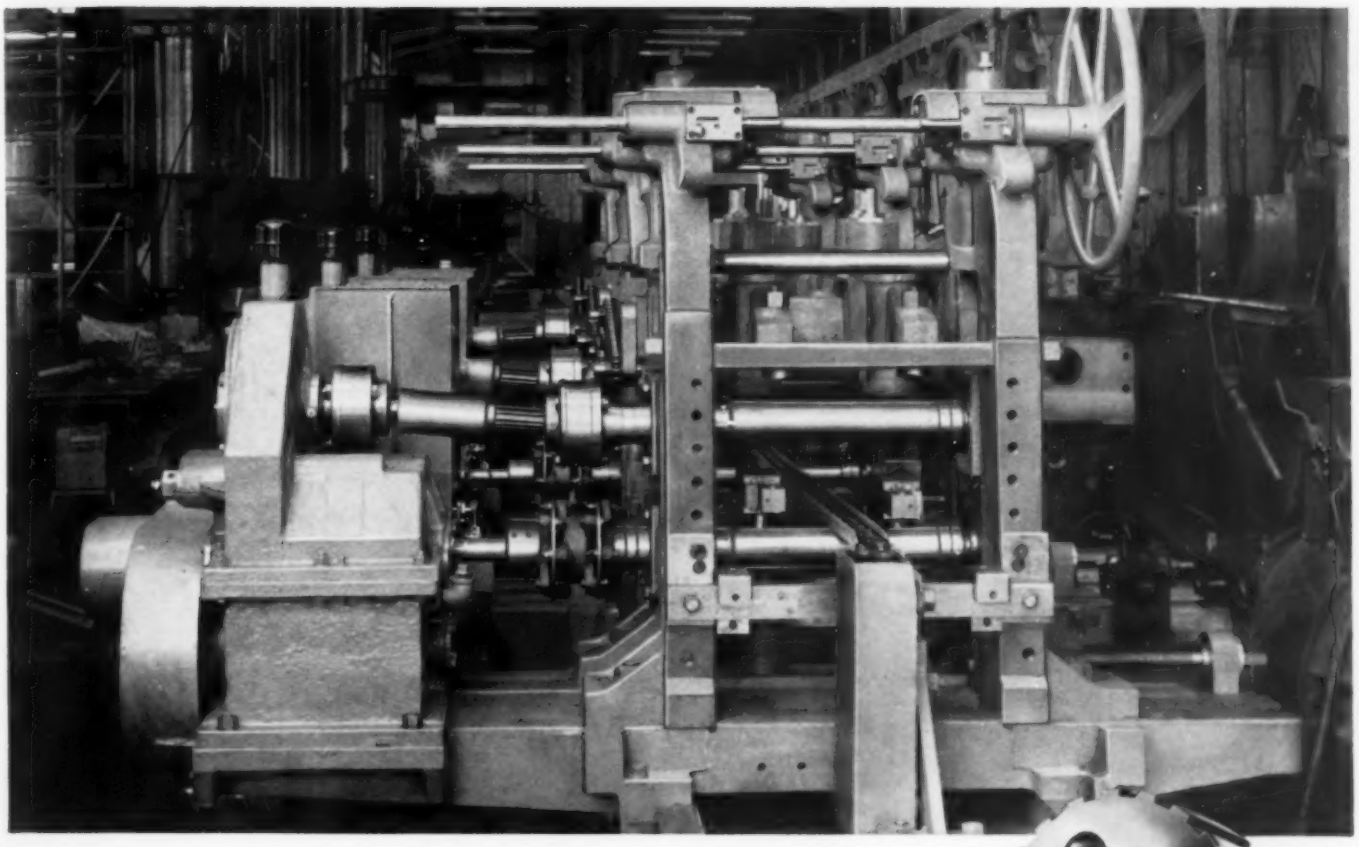
How RZEPPA constant velocity universal joints help provide scratch-free aluminum extrusions



PROBLEM:

This equipment—built by the Sutton Engineering Company, Pittsburgh—is the answer to a problem common to processors of extrusions: how to correct cross-sectional distortions that occur in the extrusion and heat treatment of today's complex shapes.

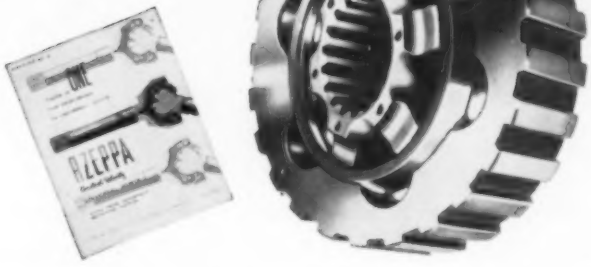
SOLUTION:

Sutton solved this problem with their new concept of giving accurately-proportioned torque to the top and bottom rolls through differential gearing.

Rzeppa Constant Velocity Universal Joints were added to overcome scratching and gouging caused by the irregular action of ordinary universal joints. Rzeppa Joints are giving scratch-free finishes even at extreme operating positions.

Other *modern design* advantages offered by Rzeppa include:

- INCREASED SPEEDS
- REDUCED DOWN-TIME
- LOWER MAINTENANCE
- HIGHER CAPACITIES



If you would like to know more about the outstanding capabilities of Rzeppa Constant Velocity Universal Joints, write today for your free copy of this complete, informative brochure.

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CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE COMPANY

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add up to
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(N.E.C. TYPE AVA) # QUALITY

Pictured is the application of fluffy asbestos prior to the impregnating and compressing process.

Impregnated asbestos compressed and felted to a smooth homogeneous wall ensuring long cable life.

Compounds — specially selected compounds — which are used to impregnate asbestos walls, are one of the important reasons why you can count on Rockbestos A.V.C. for dependable, long lasting service.

For this impregnation, Rockbestos engineers not only set up rigid compound specifications but conduct a continuing testing program to insure that these standards are always met. Thus, the exactly right compound is applied to the asbestos wall at the correct temperature and at the correct pressure. *The Result . . . the seamless, felted Rockbestos wall.*

In Rockbestos A.V.C. impregnated felted asbestos walls seal varnished cambric tapes away from air and moisture. The tapes are made to Rockbestos specifications and are applied under controlled methods assuring uniform dielectric strength.

Rockbestos A.V.C. gives you long life and dependable service under every type of operating condition . . . in temperatures up to 230°F.

Complete construction and test specifications of Rockbestos A.V.C. are in the new booklet "Specification RSS-88". Write today for your copy.

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BOOK REVIEWS

(*Continued from page 249*)

lar attention, behaviour up to collapse of continuous stanchions is described, and a design method for multi-storey frames is outlined. New buildings designed plastically are described. The text is amply supported and explained by tables, equations, pictures, and line drawings.

"Coalmining" by I.C.F. Statham has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 564 pages, 5½ x 9 in., is cloth bound and sells for $15.00. This book presents a picture of the coal mining industry in Britain, and points out the many directions progress is being made in this field. It deals with the subject from both the human and technical aspects, but emphasis has been placed on the practical end of the work. As far as possible, mathematical problems are replaced by careful descriptive passages incorporating the basic theory and illustrating the application of the theory. There is a profuse use of illustrations to portray the latest developments in machinery and techniques.

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INDEX TO ADVERTISERS

OCTOBER, 1956

A

Adams Co., Inc., R. P. 258
Aetna-Standard Engineering Co. 1
Alliance Machine Co. 42, 43
Allis-Chalmers Manufacturing Co. 8, 9, 159, 201
Alter Co., The 157
American Air Filter Co. 160
American Brakeblok Division, American Brake Shoe Co. 198
American Shear Knife Co. 243
Ampco Metal, Inc. 194
Askania Regulator Co. 199
Atlantic Refining Co., The 44
Atlas Car and Manufacturing Co. 237
Automatic Transportation Co. 18

B

Babcock and Wilcox Co., The 38, 165
Bailey Meter Co. 251
Bearings, Inc. 187
Berry Bearing Co. 202
Birdsboro Steel Foundry and Machine Co. 238, 239
Blaw-Knox Co., Foundry and Mill Machinery Division 40, 41, 214
Bliss Co., E. W. 208
Bloom Engineering Co., Inc. 196
Bristol Co., The 10
Brooks Oil Co. 34
Browning and Co., Inc., Victor R. 177
Buffalo Forge Co. 184
Bussmann Manufacturing Co. 172, 173

C

Chemical Construction Corp. 255
Chicago Concrete Breaking Co. 174
Cities Service Oil Co. 186
Clark Controller Co. 3
Cleveland Crane and Engineering Co. 48
Cleveland Worm and Gear Co., The Cover 3
Corhart Refractories Co. 154
Cunningham Co., M. E. 250
Cutler-Hammer, Inc. Cover 2

D

DeLaval Steam Turbine Co. 242
Diamond Power Specialty Corp. 234
Documentation and Licenses, Paris, France 52
Dowell, Inc. 180
Dravo Corp. 2, 250
Drever Co. 175

E

Eaton Manufacturing Co. 211
Electric Controller & Mfg. Co., Division Square D Co. 20, 169
Electric Furnace Co., The 235
Elliott Co. 27
Euclid Electric and Manufacturing Co. 258

F

Farrel-Birmingham Co., Inc. 28
Flinn and Dreffein Engineering Co. 52
Flood City Brass and Electric Co. 240
Frantz Co., Inc., S. G. 249

G

Gear Grinding Machine Co. 259
General Electric Co. 14, 15, 36, 37
General Refractories Co. 33
Great Lakes Carbon Corp. 213
Gulf Oil Corp. 24
Guyan Machinery Co. 240

H

Hagan Corp. 30, 31
Hallden Machine Co., The 52
Harbison-Walker Refractories Co. 19
Harnischfeger Corp. 254
Homestead Valve Manufacturing Co. 227
Hyde Park Foundry and Machine Co. 247

I

Industrial Gear Manufacturing Co. 226
Ironsides Co., The 50, 51

J

Johns-Manville Corp. 29

K

Kaiser Aluminum and Chemical Corp. 4, 5
Koppers Co., Inc. 35

L

Larco, Inc. 216
Lawrence Copper and Bronze Co. 244
Lectromelt Furnace Co. 154
Link-Belt Co. 46, 241
Loewy-Hydropress Division, Baldwin-Lima-Hamilton Corp. 163

M

Mackintosh-Hemphill Division, E. W. Bliss Co. 47
Mannesmann-Meer Engineering and Construction Co. 183
Manning, Maxwell and Moore, Inc. 230
Markal Co. 243
Master Builders Co., The 250
McGregor-Michigan Corp. 231
McKee and Co., Arthur G. 221
McKiernan-Terry Corp. 204
Mesta Machine Co. Cover 1
Michigan Tool Co., Cone-Drive Gears Division 195
Miles and Partner, John, London, Ltd. 52
Minneapolis-Honeywell Regulator Co. 12, 13
Morgan Construction Co. 23
Morgan Engineering Co., The 32

N

National Carbon Co., Division Union Carbide and Carbon Corp. 11
National Electric Coil Co. 185
National Roll and Foundry Co. 225
Northern Engineering Works 200

O

Ohio Steel Foundry Co. 190
Okonite Co., The 248

P

Pangborn Corp. 176
Pennsylvania Transformer Co. 236
Poole Foundry and Machine Co. 264
Post-Glover Electric Co. 256
Pratt and Whitney Co., Inc. 178, 179

R

Ramtite Co., The 45
Refractory and Insulation Corp. 192
Reliance Electric and Engineering Co. 188
Rockbestos Products Corp. 260
Rockwell Co., W. S. 255
Rust Furnace Co. 149
Rust-Oleum Corp. 39

S

Selas Corp. of America 170
Square D Co., EC&M Division 20, 169
Stamco, Inc. 249
Stearns Electric Corp. 205
Sun Oil Co. 151, 152
Surface Combustion Corp. 228, 229
Swindell-Dressler Corp. 207

T

Taylor Chain Co., S. G. 249
Taylor Sons Co., Charles, The 246
Taylor Instrument Co. 222, 223
Texas Co., The Cover 4
Timken Roller Bearing Co. 224
Torrington Co., The 6
Trabon Engineering Corp. 232
Treadwell Construction Co. 166

U

Union Carbide and Carbon Corp., National Carbon Co. 11
United Engineering and Foundry Co. 17
United States Graphite Co. 203

V

Vaughn Machinery Co., The 189

W

Wagner Electric Corp. 193
Waterbury Farrel Foundry and Machine Co. 245
Wean Engineering Co., Inc., The 52
Wean Engineering Co. of Canada, Ltd., The 52
Wean Equipment Corp. 52
Western Gear Corp. 253
Western Precipitation Corp. 197
Westinghouse Electric Corp. 217, 218, 219, 220
Wheelabrator Corp. 206
Wilson Engineering Co., Inc., Lee 7, 16

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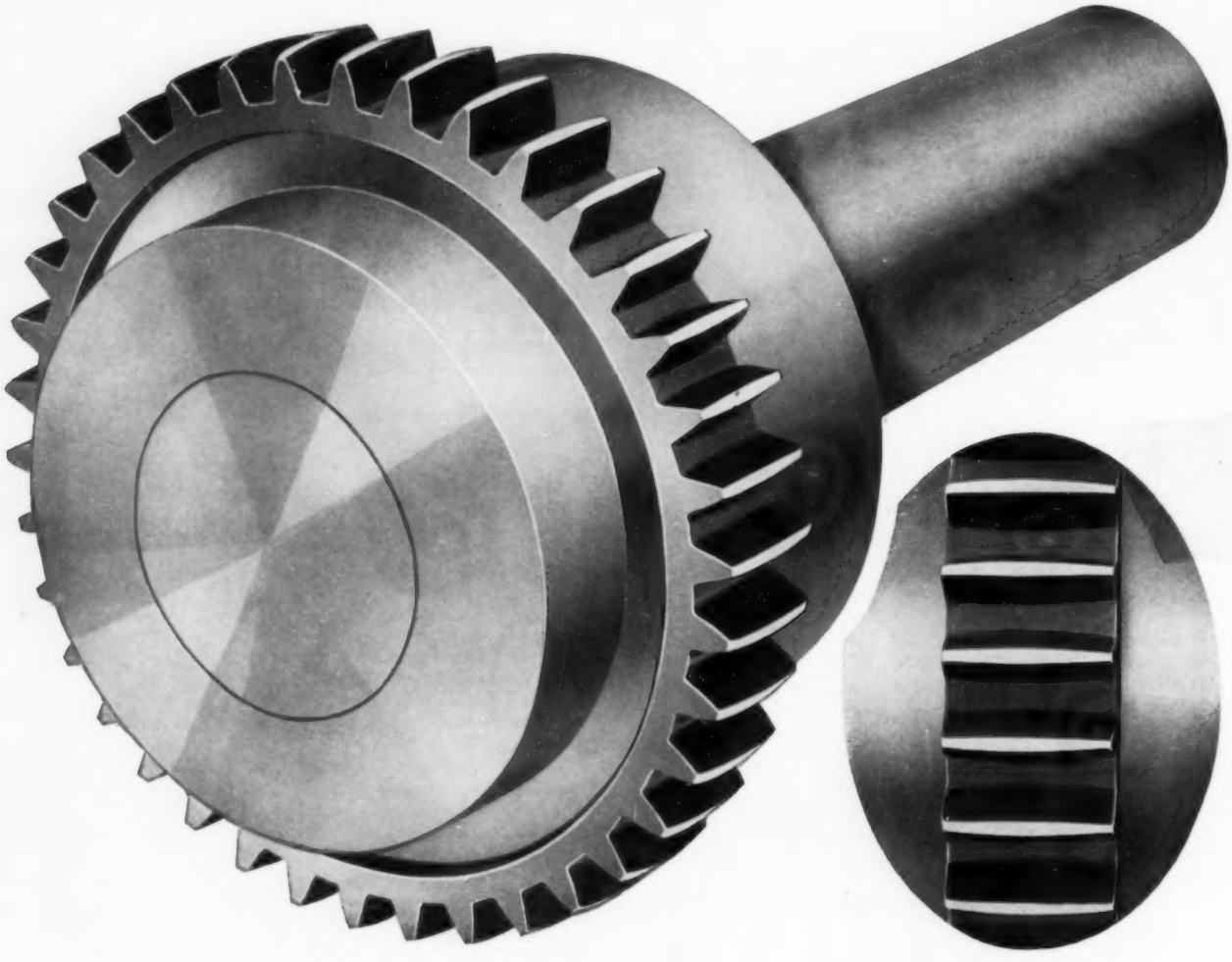

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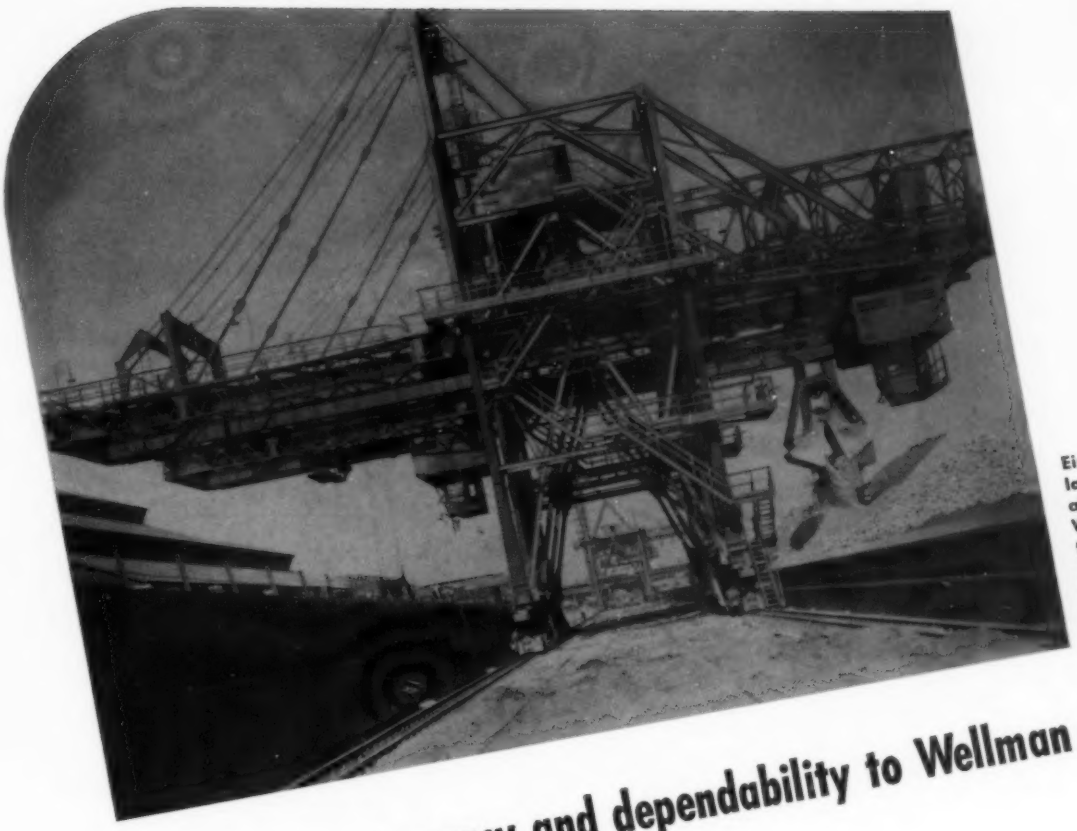

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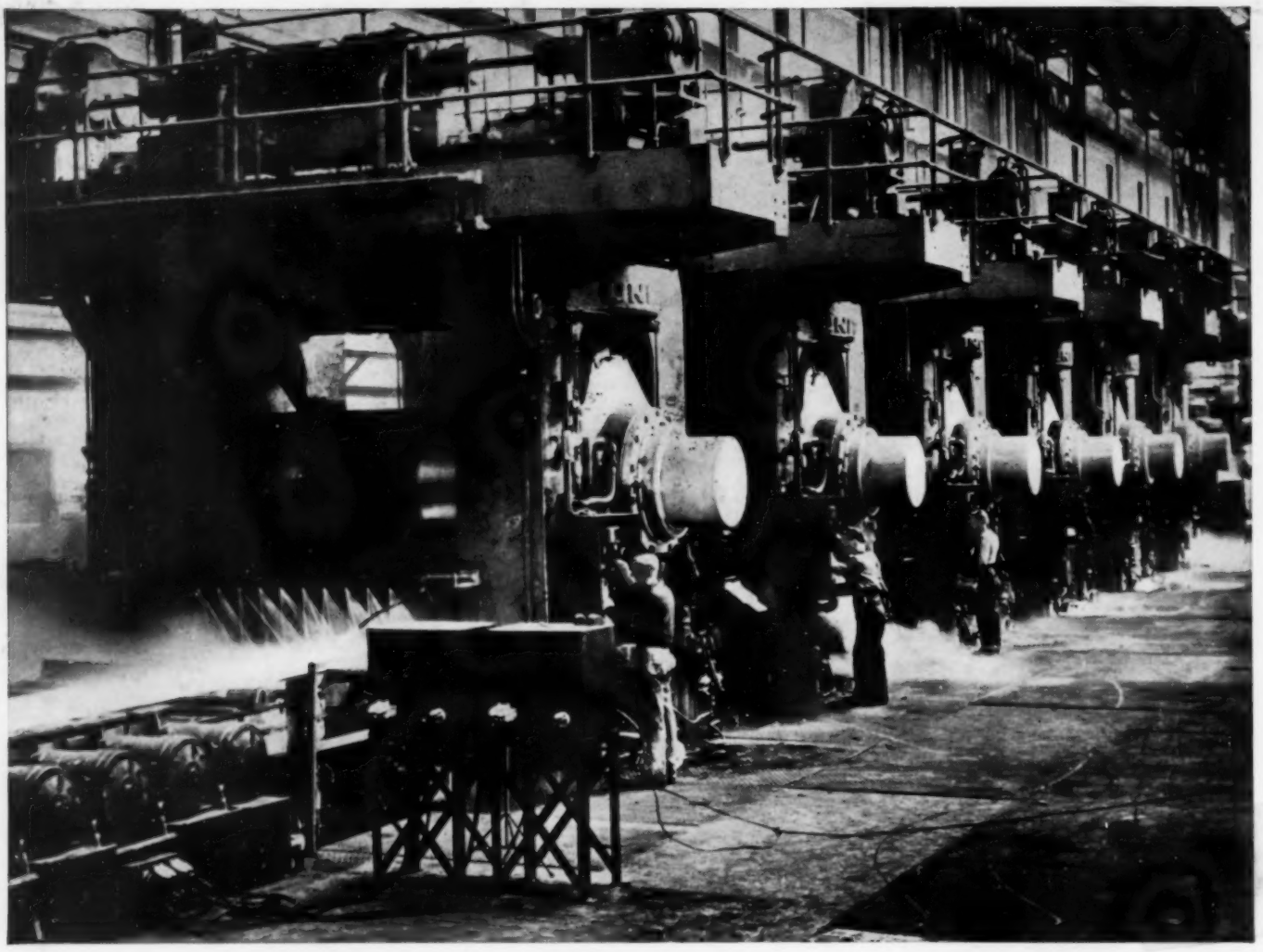

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